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THE BIDDULPHOID FORMS OF NORTH AMERICAN DIATOMACEÆ.

BY CHARLES S. BOYER, A.M.

The following article was prepared at the request of the editors of the *Systematic Botany of North America.* It is intended to be a description of all forms of the group found along the coast, excluding the West Indies, and of the fossil diatoms of California, Virginia, Maryland and New Jersey. Some, although not new, have not been hitherto described, while others have appeared in volumes difficult of access or long out of print. In the examination of the bibliography the confusion appeared to be so great that it was thought best to describe all forms from specimens in my collection. This labor has been lightened by the use of the *Habirshaw Catalogue* and of the admirable *Sylloge Algarum* of De Toni. All citations given in either of these works have been, with a few exceptions, carefully examined. It has been my purpose to give the first description and figure published and to add one or two citations to the best illustrations, especially to Schmidt's *Atlas.*

The classification adopted is, for the most part, that of Dr. Van Heurck and Prof. H. L. Smith. No changes have been made in the nomenclature except those demanded by the law of priority.

My thanks are due to Mr. F. J. Keeley, for slides and photographs; to Mr. Lewis Woolman, for numerous deposits from the artesian wells and other localities, and, especially, to Mr. John A. Shulze, for many vials of finely prepared material and for specimens contributed from his collection.[1]

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[1] For the history of the growth and reproduction of these forms the student is referred to Kützing, Rabenhorst, Van Heurck and Pfitzer. My own observations have been confined to *Biddulphia lævis*, a gathering of which, sent me by Mr. T. Chalkley Palmer, from Reedy Island, Delaware river, admirably illustrated the special cells corresponding to the "sporangium" of authors. Certain of the ordinary cells had apparently assumed a new function, expanding into spherical bodies three or four times the diameter

Family DIATOMACEÆ.

Sub-Family CRYPTO-RAPHIDIEÆ.

Tribe BIDDULPHIEÆ.

Frustules usually concatenate, more often found free. Zonal view well developed, generally quadrangular. Valvular view elliptical, angular or suborbicular. Surface varying from finely granular or punctate to coarsely reticulate. Angles well developed and usually conspicuous, frequently elevated into horns or processes.

Sub-Tribe I. Isthmiæ.

Frustules large, trapezoidal in zonal view, adherent to each other by short mucous stipes, forming irregularly zigzag filaments. Represented by but one genus.

1. Isthmia.

Characters of sub-tribe.

Sub-Tribe II. Biddulphiæ.

Frustules concatenate or attached by alternate angles. Valves with or without processes, spines or costæ, but without transverse internal septa. Surface definitely marked with reticulations, granules or puncta.

2. Biddulphia.

Angles usually elevated into horns or processes or distinguished by markings from the central portion.

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of the normal cell and terminating the filaments. These spherical cells contained granular masses and corresponded to the enlarged cells of *Melosira varians*. From observations made in *Eunotia pectinalis* for several years, I believe that the granular masses found in many cells while in an absolutely fresh condition are extruded by the partial separation of the connective zones, and that there are formed later either new frustules by rejuvenescence or by conjugation with other masses external to the filaments. The cells from which these granular bodies emerge, after forming into one or two larger spheres, are the fertile cells and are found in either larger or smaller filaments. Examinations of material gathered at hourly intervals for many successive days lead me to disbelieve in the theory of gradual diminution of the frustules, and rather to accept the conclusion that they really increase in size and that the flexibility of the connective zone will allow of a variation.

Sub-Tribe III. Terpsinöeæ.

Frustules regularly concatenate. Valves distinguished by the presence of transverse internal septa. Surface without spines.

3. Porpeia.

Valves elevated into a rounded projection at each end. Zonal view showing septa which are straight or curved.

4. Terpsinöe.

Surface of valve flat and indefinitely granulate. Outline more or less undulate. Septa curved at the ends and usually resembling musical notes.

5. Hydrosera.

Outline of valve elliptical or triangular, the angles separated from the centre by short septa. A single indefinite and indistinct septum usually found projecting from one of the sides.

6. Anaulus.

Valves elliptical or arcuate, with prominent and robust septa.

7. Huttonia.

Valves with truncate processes and transverse partial septa.

Sub-Tribe IV. Hemiaulidieæ.

Valves usually distinguished by the separation of central part from the ends or angles by costæ or depressions; processes often present, varying much in length and frequently tipped with a curved spine. Valves elliptical or angular, coarsely punctate.

8. Hemiaulus.

Valves elliptical or triangular, with or without transverse costæ. Processes prominent.

9. Ploiaria.

Valves without processes, inflated at the centre.

Sub-Tribe V. Eucampieæ.

Frustules concatenate in straight or spiral lines. Surface of valve undulating. Markings granular, generally indefinite. Connective zone frequently annulate.

10. Graya.

Valves elliptical, with undulating surface.

11. Eucampia.

Valves elliptical with undulating surface, and connected in a spiral chain.

Sub-Tribe I. Isthmiæ.

I. ISTHMIA Ag. (1832).

Valves dissimilar and unequal, elliptical or ovate. In one valve the surface is elevated at one end into a protuberance or " beak;" in the other there is simply a gradual elevation toward one end. Surface coarsely cellular, except at the " beak," where the cells are much smaller. The ultimate structure of each cell appears to be that of a " delicate, perforated membrane," of more or less elliptical outline and with various arrangements of the perforations.[2]

In zonal view the frustules are more or less rhomboidal or trapezoidal, without definite relation between the width and length.

Connective zone varies greatly in width and is frequently persistent, so that at the same time what appears at first to constitute one frustule may be found to contain the two older valves with their connective zones and two new valves with, possibly, their connective zones.

Analysis of Species.

Valves costate, ... 1. *nervosa.*
Valves not costate:
  Rhomboidal in zonal view, ... 2. *obliquata.*
  Irregularly ridged as to one valve, ... 3. *minima.*

1. Isthmia nervosa Kütz.

Isthmia nervosa Kütz., Bacill. (1844), 137, Pl. 19, fig. 5; Schmidt, Pl. 135; Pl. 145, figs. 10, 11.
Diatoma obliquatum Lyng, Hydrophyton Dan., 181, in part.
Isthmia obliquata (Lyng) Ag., Consp., 55, in part.

Valves traversed from the margin toward the centre by costæ, which vary in number from 10 to 50. Av. l. of fr. .264 mm., av. l. of v. .198 mm. Cells of the connective zone much larger on the border.

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[2] For details of structure v. Nelson and Karop's "Notes of Finer Structure," etc., *Journal of Quekett Club,* Ser. 2, Vol. 2, p. 269, and Vol. 3, p. 41; also, Dr. Stokes on "Minute Structure of Certain Diatoms" in *Observer,* 1894, p. 369; and on "The Structure of the Diatom Girdle," by Palmer and Keeley, in the current volume of the PROCEEDINGS of the Academy, p. 465.

Coast of California, where it is abundant; Leete's Island, Conn. (Terry); Rockaway, L. I. (Terry); Rivière du Loup (Lewis); L. I. Sound (Lewis); Newport, R. I., *in situ* (Lewis); Boston Harbor (Bailey); Portland, Me. (J. A. Shulze); Hudson Strait (J. A. Shulze). Its occurrence on the Atlantic coast is extremely rare. Fossil in the Miocene deposits of California.

2. **Isthmia obliquata** (J. E. Smith).

Conferva obliquata Smith, Eng. Bot. (1814), Pl. 1869.
Diatoma obliquatum Lyng, Hydrophyt. Dan., 181, in part.
Isthmia obliquata (Lyng) Ag., Consp., 55.
Isthmia enervis Ehr., Inf., 209; Schmidt, Pl. 136, figs. 1, 3, 6, 7.
Isthmiella enervis (Ehr.) Cleve, Diat. Arct., 10.

Valves as in *nervosa*, except that the costæ are absent. The cells of the "beak" are not usually so small relatively as in *nervosa*, while those of the connective zone are smaller and the reticulations of the entire surface appear more angular.

Honduras (Janisch, Rabenhorst), and probably to be occasionally found southward. As Ralfs remarks, *nervosa* appears to be the northern and "*enervis*" the southern species.[3]

3. **Isthmia minima** B. and H.

Isthmia minima Bailey and Harvey, Wilkes' Expedition (1862), 176, Pl. 9, fig. 11; Schmidt, Pl. 145, fig. 9.
Isthmiella minima (B. and H.) De Toni, 835.
Isthmia Lindigiana Grun. and Eul., Hedwigia, 6, 29; Schmidt, Pl. 145, figs. 1, 2, 3.
Isthmia capensis Grun., Schmidt, Pl. 136, fig. 4, Pl. 145, fig. 4.

Frustules smaller and usually more elongated than in *nervosa* and *obliquata*. Opposite valves showing greater inequalities, one valve almost invariably having ridged elevations. Connective zone with rather minute cells and usually without a border of larger cells. Cells of valve average $1\frac{1}{2}$ in .01 mm. Cells of connective zone average 3 in .01 mm. L. of fr. .231 mm. L. of v. .013 mm. Secondary markings consist of minute puncta arranged in longitudinal rows within the reticulations. Certain valves from Barbados which appear similar to the present species are without doubt distinct, having a rather coarse cellular reticulation within the cells which thus appear beautifully stellate.

Not uncommon in Campeachy Bay, Honduras and southward.

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[3] The forms usually known as *nervosa* and *enervis* are, as remarked by Wm. Smith, "inextricably confused," but the figure given by J. E. Smith in *English Botany*, Plate 1869, under the name *Conferva obliquata*, is undoubtedly *enervis*, as it does not show the costæ, and, by the law of priority, the specific name of *obliquata* should be retained for the forms without costæ.

Sub-Tribe II. Biddulphiæ.

BIDDULPHIA Gray (1831) em. V. H. (1885).

Valves usually with processes which are globular, conical or cylindrical, obtuse or truncate, or with spines imitating slender processes. When processes are absent, the angles or ends of valves, either by elevation or by variation in punctation, resemble them.

The following analytical key to the species is artificial. While the uncertainty as to the relations of these forms exists, it is difficult to group them. At the same time, it will be seen that the genus divides itself, more or less naturally, into groups represented by such forms as *Biddulphiana, Mobiliensis, Favus, turgida, Circinus, arctica, vesiculosa, Tabellarium, trisulca, condecora, parvula* and *semicircularis.*

It seems unnecessary to separate the forms once included under *Denticella* and *Odontella.* The genus *Triceratium* is necessarily abandoned, the genus *Amphitetras* is no longer useful and the only two groups which appear to be sufficiently distinct are *Zygoceros* and *Cerataulus,* the former differing, however, from *Biddulphia* only in the absence of true processes, while the latter is Biddulphoid in form, but appears to be a transition to *Auliscus.* I have, therefore, followed Prof. H. L. Smith and Dr. Van Heurck in uniting all the genera mentioned under *Biddulphia.* Although, as has been remarked, an enormous number of species is thus included, the distribution of many, hitherto considered as belonging to *Triceratium,* under non-Biddulphoid genera will probably result in a greater restriction than would be the case if most angular forms are classified as *Triceratia.*[4]

Analysis of Species.

1. Valves divided into three or more parts. Processes globular (*Biddulphia* proper).
    - Divisions of valve not elevated, . . . 1. *Biddulphiana.*
    - Divisions of valve elevated into rounded protuberances:
        - Cells regularly disposed and rounded, . . 2. *tridens.*
        - Cells irregularly disposed, pustuliform, . 3. *pustulata.*

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[4] Various authors give "Bermuda" as a locality of fossil species. Reference to the islands of Bermuda is a mistake, as they are of coral formation, and contain no fossil deposits. It should be regarded as indicating Nottingham, Md., and its immediate vicinity, which is situated in what is known as "Bermuda Hundred."

2. Valves not divided into parts. Usually furnished with spines. Processes more or less conical and obtuse. Surface not coarsely reticulate (*Odontella* and *Denticella*, in part):
Spines very numerous and prominent:
Valves broadly elliptical, ... 4. *multicornis.*
Valves narrowly elliptical, ... 5. *Brittoniana.*
Spines few but long and prominent:
Spines usually two on each valve:
Projecting from central elevation, . . 6. *longicruris.*
Projecting from small conical elevations near the extremities, ... 7. *Mobiliensis.*
Spines usually six or eight, ... 8. *longispina.*
Spines small, usually few, or sometimes wanting:
Valves elliptical:
With central elevation, ... 9. *aurita.*
Without marked elevation, ... 10. *obtusa.*
With central depression or simply convex:
Spines absent, ... 11. *Roperiana.*
Spines in circlet at centre, ... 12. *Argus.*
Spines one or two near opposite margins:
Surface with spurs, ... 13. *Edwardsii.*
Surface without fine spurs, . . 14. *Cookiana.*
Surface divided by two transverse hyaline lines,
15. *interrupta.*
Spines curved, one near each process, . . 16. *granulata.*
Spines three to six, valve divided longitudinally,
17. *seticulosa.*
Valves rhomboidal or angular, surface with small spurs:
Processes hornlike, obtuse, valves 3–4-angled,
18. *spinosa.*
Processes small, short, ... 19. *Rhombus.*
Valves suborbicular, ... 20. *suborbicularis.*
Valves orbicular, ... 21. *Smithii.*

3. Valves usually as in 2, but with surface coarsely reticulate (*Triceratium*, in part):
Processes conical and obtuse:
Valves angular:
3–4-angled, l. of s. 15 mm. or less, . . 22. *Favus.*
3–7-angled, l. of s. usually exceeding 15 mm.,
23. *grandis.*

3-angled, small, with more acute processes, 24. *acuta.*
3–4-angled, sides convex, usually with stout spines, 25. *Robertsiana.*
5-angled, small, sides turgid, . . 26. *Campeachiana.*
Valves elliptical or rhomboidal:
Without spines:
Rhomboidal with turgid sides, reticulations 2 in .01 mm., ... 27. *dubia.*
Rhomboidal or elliptical, reticulations 1 to 1½ in .01 mm., ... 28. *reticulata.*
With two or three spines near the margin:
Surface depressed at centre, . . 29. *Peruviana.*
Surface not depressed, ... 30. *Keeleyi.*

4. Valves with cylindrical, truncate processes, appearing hyaline at the apex (*Cerataulus*, in part):
Valves angular:
Reticulations coarse, hexagonal, . . . 31. *consimilis.*
Reticulations fine:
Processes short, truncate, . . . 32. *convexiuscula.*
Processes large, elevated, ... 33. *orbiculata.*
Valves elliptical (or rarely angular):
Reticulations coarse, ... 34. *verrucosa.*
Reticulations fine:
With two stout spines, surface spurred, . 35. *turgida.*
Without strong spines, ... 36. *Californica.*
Surface without spurs:
Valves small, without spines, . . 37. *ovalis.*
Valves small, with two small spines, one near each side, ... 38. *lœvis.*
Valves large, without spines, . . 39. *Thumii.*

5. Valves with processes replaced by spines (*Zygoceros*):
Valves elliptical, ... 40. *Circinus.*
Valves suborbicular, ... 41. *quadricornis.*

6. Valves without true processes. Reticulations more or less angular or irregular, those of the angles differing from those of the central portion (*Triceratium*):
Valves elliptical, ... 42. *Balœna.*
Valves angular, with or without central elevations, 43. *arctica.*

Valves triangular, with central and angular elevations, 44. *Heilpriniana.*

7. Valves mostly as in 6, but usually with very short, truncated processes, which are hyaline at the ends (*Amphitetras*):
Valves without web-like markings:
4–5-angled, ... 45. *vesiculosa.*
Rhomboidal, ... 46. *decipiens*
Valves with web-like markings:
Markings producing appearance of inscribed square:
Reticulations about 5 in .01 mm., . . 47. *elegans.*
Reticulations about 2½ in .01 mm., . 48. *biquadrata.*
Markings not producing appearance of square:
Valves 4–5-angled, ... 49. *Pentacrinus.*

8. Valves angular, the angles not elevated, separated from central part by more or less definite costæ (*Triceratium*):
Costæ dividing angles from centre, . . . 50. *Kainii.*
Costæ extending but short distances from sides:
Of the same length, usually curved, . 51. *Tabellarium.*
Indefinite in length and direction, . . . 52. *alternans.*

9. Valves with round, scattered puncta. Angles elevated into rounded processes (*Triceratium*):
Without septa, ... 53. *trisulca.*
With partial septa, ... 54. *costulata.*

10. Valves without marked elevation of surface and not divided by costæ or otherwise. Angles without processes. Spines usually absent. Puncta generally indefinite, irregular and unequal (*Triceratium*):
Valves flat:
Puncta in radiating, undulating rows, . 55. *condecora.*
Puncta rounded or subquadrate, not undulating, outline suborbicular, ... 56. *subrotundata.*
Outline triangular, with more or less unequal sides which are often sinuous, . . . 57. *Americana.*
Outline 5–6-angled, ... 58. *Antillarum.*
Puncta interspersed with much finer puncta, 59. *interpunctatum.*
Puncta of one angle much smaller than those in the other two, ... 60. *hebetata.*

Puncta crowded at the angles and in parallel rows at the margin, ... 61. *heteropora.*
Valves with slight elevations at the angles and often at the centre:
Puncta much finer at the angles, . . . 62. *tessellata.*
Puncta nearly equal, ... 63. *Reticulum.*
Puncta irregular, unequal and scattered, . 64. *inelegans.*
11. Valves as in 10, but with surface mostly hyaline, except at the centre and angles where the puncta are minute, 65. *parvula.*
12. Valves semicircular or arcuate, more or less elevated at the ends, and with mostly coarse, radiant puncta, 66. *semicircularis.*
13. Valves elliptical, coarsely punctate, usually traversed by hyaline lines:
Hyaline lines prominent, ... 67. *Testudo.*
Hyaline lines indistinct, one at each end, . 68. *Shulzei.*

1. **Biddulphia Biddulphiana** (Smith).

Conferva Biddulphiana Smith, Eng. Bot. (1807), Pl. 1762, (upper figs).
Biddulphia pulchella Gray, Arr. Brit. Plants, I, 294; Schmidt, Pl. 118, figs. 26–32, Pl. 121, figs. 1, 2,
Diatoma Biddulphianum Ag.
Diatoma interstitiale Ag.
Diatoma liberum Ag.
Denticella Biddulphia Ehr.
Biddulphia trilocularis, quinquelocularis and *septemlocularis* Kütz.
B. Australis Mont.
B. elongata Menengh.
B. fasciata, unifasciata and *transversa* Wigand.

Valve, in general outline, elliptical. Surface convex, divided tranversely by two or more costæ. Sides undulating, the undulations, which are sometimes angular, corresponding to the divisions of the surface. At each end a process rises which is more or less globular, constricted at the base. The centre of the valve, usually not so elevated as the processes, bears a few rather short spines. Surface reticulated, the reticulations coarse, equalling .003 mm. in diam., except at the centre, where they are usually smaller and arranged more or less concentrically around a somewhat elliptical, panduriform or oblong space which is transverse to the major axis of the valve. On the processes the reticulations are minute. Between the coarse reticulations occur minute puncta.

Zonal view quadrangular, the connective zone having smaller reticulations, about 5 in .01 mm., arranged in nearly parallel vertical rows. L. of v. averages .115 mm.

A species variable in size, outline and the number of costæ. In a specimen from Campeachy Bay the costæ are connected by anastomosing lines.

Common along the Atlantic coast, especially southward. Fossil in the Miocene deposits of California and New Jersey, and in later deposits at Pensauken, N. J., and the blue clay of the Delaware river.

2. **Biddulphia tridens** Ehr.

Biddulphia tridens Ehr., Abhand. Ber. Akad., 1838, 129.
Denticella tridens Ehr., Abhand. Ber. Akad. (1839), 73.
Denticella tridentata Ehr., Abhand. Ber. Akad. (1844), 79.
Denticella polymera E., Abhand. Ber. Akad. (1844), 266.
Odontella polymera Kütz., Bacill., 137.
Zygoceros Tuomeyi Bail., Sil. Jour. (1844), Pl. 3, figs. 3, 4, 8.
Denticella polymera (Ehr.) Bail., Sil. Jour. (1845), 342.
Denticella simplex Shadb., T. M. S (1854), Pl. 1, fig. 16.
Denticella margaritifera Shadb., T. M. S., Pl. 1, fig. 17 (1854).
Biddulphia tridentata Ehr., Mik., Pl. 18, fig. 52.
Biddulphia Tuomeyi (Bail.), Roper, T. M. S. (1859), 8; Schmidt, Pl. 118, figs. 1–7, Pl. 119, figs. 1–7, 15, 17.
Biddulphia elegantula Grev., T. M. S. (1865), 50.

Valves rhombic-lanceolate, divided by septa into three or more divisions, the centre one always largest, the undulations of the sides corresponding to the divisions. Surface coarsely granular. In zonal view the divisions of the valves are seen to consist of more or less hemispherical elevations, becoming gradually smaller as a rule toward the ends. Processes usually rising higher than the elevations, varying from short to slender and generally inflated at the base. From the central elevation two or more slender, rather short spines arise, and frequently smaller spines are seen in the other elevations.

Variable in size, the valve, in the form of *elegantula*, reaching a length of .3 mm.

The distinction between *B. pulchella* and *B. tridens* may be said to consist chiefly in the surface reticulation, in the elevation of the septate divisions and in the outline. In *tridens*, all of the septate divisions are usually more or less elevated, while in *pulchella* the central one only is so found. The outline of *tridens* is rhombic, while that of *pulchella* is elliptical. There are forms, especially in the Redondo Beach (Cal.) material, which appear to be intermediate.

Common along the South Atlantic coast of North America. Fossil in the Miocene deposits of California, Virginia, New Jersey and St. Augustine, Fla.

In a note on "Ehrenberg's Observtions on the Fossil Infusoria of Virginia and Maryland," etc., in *Sil. Jour.* (1845), Prof. Bailey states (p. 204) that, in a letter received, Ehrenberg says that *Zygoceros* (*Biddulphia*) *Tuomeyi* equals *Denticella tridentata.* Ehrenberg (*Mik.*, Pl. 21, fig. 24) gives *Biddulphia tridentata* as equaling *Denticella tridens.* The figure prevents it from being considered as *Biddulphia pulchella*, as suggested by De Toni (*Syll.*, p. 870).

Roper remarks: "In examining the synonymy of this species, Ehrenberg's name of *Denticella tridens* appears to have the priority as to date, but as it occurs not infrequently with only one lobe and occasionally with ten or twelve, as shown in the *Denticella polymera* of *Am. Jour. of Science*, Vol. xlviii, tab. iv, fig. 20, clearly only a large specimen of the present form, the designation *tridens* is so decidedly inapplicable that I am induced to retain that of *Tuomeyi*, given by Prof. Bailey." The reason for the violation of the law of priority I do not consider sufficient, because, in the first place, a descriptive specific name cannot, in many cases, apply to all variations, and, in the second place, because, if all the variations included by Roper and others are accepted as forms of one species, it will be found that Ehrenberg's form of *tridens* is so abundant in recent and fossil deposits that it may be considered a type form.

Greville states that the form of *elegantula* differs from *B. Tuomeyi* "in the almost filiform horns, not inflated at the base, and which form a right angle with the base of the valve as in *Hemiaulus.*" In a specimen from the artesian well at Atlantic City I have noticed that while one process is not inflated, the other is as much so as in many type forms of *B. tridens.* It would appear that in some cases the process is extended after the valve apparently intended to expand merely into an elevation, and that the inflation is occasionally accidental. As *elegantula* is variable in the number of inflations or lobes, there appears to be no way of separating it from *B. tridens.* I have, therefore, concluded to unite all the forms.

A peculiar form, the photograph of which was kindly sent me by Dr. Ward, of Poughkeepsie, shows the valve with three elevations and with short slender processes extending from much-inflated bases which appear similar to the usual elevations. The valve is arched longitudinally. In a form from Szakal, Hungary, the arching of the valve is lateral. It may be considered doubtful whether the numerous variations in *B. tridens* exceed those found in many other species of *Biddulphia.*

3. **Biddulphia pustulata** Brun.

Biddulphia pustulata Brun, Diat. Esp. Nouv., 13 (1891), Pl. 13, fig. 10.

Valves rhombic-lanceolate, divided by septa into three or more divisions, as in *B. tridens*, with the central division turgid. Surface " with coarse, large, pustuliform granules, irregularly placed or grouped," which extend to the apices of the processes. Silex robust and very thick, as in *B. vittata* Gr. and St. In zonal view the appearance of valve approaches very closely *B. tridens.* L. of v. .09 to .11 mm. (From Brun's *Diat. Esp. Nouv.*, in part.)

Fossil in Miocene deposit of Atlantic City, N. J. (Brun).

4. **Biddulphia multicornis** Grun.

Biddulphia multicornis Grun., V. H. Syn. (1881), Pl. 102, fig. 7.
Biddulphia multicornis var. *Templum* Brun., Schmidt's Atlas, Pl. 173, figs. 13, 14.

Valve broadly elliptical-lanceolate, with rounded ends. Processes short, obliquely truncate. Surface convex, finely reticulated, the reticulations about 5 in .01 mm., with minute spurs at intervals, as in *B. turgida.*

Arranged in a single row along each edge of the valve are about twelve large, flattened spines, tumid at the base, extending to the opposite valve, which they closely embrace. L. of v. .2 mm.

A rare and singular species. The spines, which have the appearance of coming from the interior of the valve, are so firmly attached to the opposite valve that they leave scars upon it when separated.

Fossil in Miocene deposit of Redondo Beach, Cal.

As no illustration of the valve view of either type form or variety has been given, I am unable to distinguish between them. In the very few specimens sent me by Mr. John A. Shulze, the variations appear to be chiefly in size and in relative width of valve.

5. **Biddulphia Brittoniana** K. and S.

Biddulphia Brittoniana Kain and Schultze, Bull. Torr. Bot. Club (1889), 208, Pl. 102, fig. 1.

Valves elliptical-lanceolate, slightly convex. Surface traversed by transverse rows of indistinct puncta, about 10 in .01 mm., extending to the ends of processes which are large, cylindrical, truncate and curved in opposite directions. At the base of each process one or two strong curved spines extend, meeting the surface of the opposing valve of the next frustule and apparently acting as braces. Around the margin and along the middle of the valve extend rows of fine hairs which, meeting and interlacing with those of the next valve, unite the two valves of different frustules.

L. of v. .214 mm.

Fossil in the Miocene deposit of Atlantic City, N. J.

6. **Biddulphia longicruris** Grev.

Biddulphia longicruris Grev., T. M. S. (1859), 163, Pl. 6, fig. 10; Schmidt, Pl. 118, fig. 10.

Valve elliptical-lanceolate. Surface with a rounded elevation from which project two or more long spines. Processes long, obtuse, slightly inflated at the base. Surface with rows of puncta radiating from the centre. On the connective zone the puncta are in vertical rows.

L. of v. averages .033 mm.

Near *B. aurita*, from which it is chiefly distinguished by the much longer processes.

Occasional on the Pacific coast—" Californian guano," Grev.

7. **Biddulphia Mobiliensis** (Bail.) Grun.

Biddulphia Mobiliensis (Bail.) Grun., V. H. Syn., Pl. 101, figs. 4-6, Pl. 103, fig. *A*; Schmidt, Pl. 122, figs. 20, 21.

Zygoceros (*Denticella?*) *Mobiliensis* Bail., Mic. Obs., 40 (1850).

Biddulphia Baileyi Wm. Smith, Brit. Diat., *2*, 50, Pl. 45, fig. 322, Pl. 62, fig. 322.

Zygoceros Mobiliensis (Bail.) Ralfs, *Biddulphia tenuis* L. W. Bail., *Biddulphia trinacria* L. W. Bail., *Denticella Mobiliensis* (Bail.) Grun., *Zygoceros occidentalis* L. W. Bail., *Denticella triancria* Bail.

Valve elliptical-lanceolate. Surface convex with a flat central portion, separated from the other part of valve by a slightly elevated ridge which extends in two more or less sigmoidal lines from one process to the other. On opposite sides of this central portion, and placed at distances variable in different specimens from each process, is a small, conical projection from which extend one and occasionally two long, slender spines or bristles. Processes slender, capitate, about .023 mm. in length or about half the length of the spines. Surface of valve " delicately decussately-punctate," the markings resembing those of *Pleurosigma*, about 15 in .01 mm In zonal view the valve converges toward the central elevation. Frustules delicate, of a yellowish color, variable in size, the length of valve in American specimens averaging .066 mm.

Common in the Gulf of Mexico and southward; Savannah (Bail.); St. Augustine, Fla. (Bail.); Trichoplankton of the North Atlantic (Cleve); Fossil at Richmond, Atlantic City artesian well and in the Pleistocene clay from artesian well at Norfolk, Va.

8. **Biddulphia longispina** Grun.

Biddulphia longispina Grun., V. H. Syn., Pl. 102, fig. 6 (1881).
Odontotropis longispina (Grun.), De Toni.

Valve elliptical or elliptical-lanceolate, tapering as a frustum into a narrowly elliptical-lanceolate flattened elevation surrounded by a hyaline, unevenly notched ridge from which project robust, hollow spines, 6 or 8 in number, about .092 mm. in length. From each end of valve a slender, capitate process, about .046 mm. in length, extends. Surface of valve traversed by rows of minute granules, about 9 in .01 mm. on the elevation and 12 in .01 mm. at the sides. The granules extend in transversely parallel rows from a narrow median line to the edge of the crest and then radiate toward the circumference.

L. of v. .072 mm.

The hyaline ridge in this species is not strictly a single keel, as in *Odontotropis cristata* and *O. carinata* from the Mors deposit, but is a double elevation enclosing an elliptical central portion of valve. The general structure, in this respect, resembles that of *B. Mobiliensis* (Bail.) Grun.

Fossil at Redondo Beach and Santa Monica, Cal., and Atlantic City, N. J.

9. **Biddulphia aurita** (Lyng) Brèb.

Biddulphia aurita (Lyng) Brèb., Consid. Diat., 12 (1838); Wm. Smith, Brit. Diat., *2*, 49, Pl. 45, fig. 319, front, fig. 319; V. H. Syn., Pl. 98, figs. 4–9.
Diatoma auritum Lyng, Hydrophyt. Dan., 182 (1819), Pl. 62, fig. *D*.
Odontella aurita (Lyng) Ag., Consp., 56.
Denticella aurita Ehr.
Denticella gracilis Ehr.
Zygoceros margaritaceum B. and H.

Valve elliptical-lanceolate. Surface with an elevation at centre, generally more or less flattened at the top, from which usually a few short spines project. Processes obtuse, inflated at the base. Surface covered with rounded puncta, about 6 in .01 mm., radiating from an obscure centre. In zonal view the frustule is quadrangular, the connective zone having vertical rows of parallel puncta about 5 in .01 mm. Length of v. .082 mm. A variable species.

Common on the Atlantic and Pacific coasts.

10. **Biddulphia obtusa** (Kütz.) Ralfs.

Biddulphia obtusa (Kütz.) Ralfs, Prit. Inf., 848 (1861).
Odontella obtusa Kütz., Bacill., 137 (1844), Pl. 18, 8, figs. 1-3, 6-8.

Valve elliptical-lanceolate. Surface without marked central elevation, the centre appearing usually flattened or somewhat depressed. Processes obtuse and short, somewhat inflated at the base.

Very near *B. aurita,* from which it is chiefly distinguished by the absence of central spines and by the shortness of the processes.

As *B. obtusa* appears to include, however, according to various authors, about all the forms whose processes are not acute, the name is not particularly significant.

Atlantic and Pacific coasts.

[**Biddulphia subæqua** (Kütz.) Ralfs.]

Biddulphia subæqua (Kütz.) Ralfs, Prit. Inf., 848; Schmidt, Pl. 141, fig. 11 (not var. *Baltica,* V. H. Syn., Pl. 100, figs. 5, 6).
Odontella subæqua Kütz., Bacill., 137, Pl. 18, figs. 4, 5.

" Frustules oblong, very smooth, with minute lateral spines and without any median elevation " (Kütz.).

Campeachy Bay (Schmidt).

Prof. Smith remarks that both *B. obtusa* and *B. subæqua* " are merely forms " of *B. aurita,* and, as Ralfs says, he " is probably right."

11. **Biddulphia Roperiana** Grev.

Biddulphia Roperiana Grev., T. M. S. (1859), 163, Pl. 8, fig. 11-13; Schmidt, Pl. 120, fig. 20-24.
Odontella Roperiana (Grev.) De Toni, Syl. Alg., 863.
Triceratrium (*Odontella discigera* var.?) *Californicum* Grun.? V. H. Syn., Pl. 108, fig. 11 (?).

Valve broadly elliptical-lanceolate or triangular (?). Surface convex, with a central depression, punctate, the puncta averaging 7 in .01 mm., radiating from the centre. Zonal view quadrangular, the connective zone having puncta in vertical parallel rows. L. of v. .165 mm.

Distinguished by its prominent central depression from *B. aurita,* which it very nearly approaches.

Common on the Pacific coast. Fossil in the California deposits.

12. **Biddulphia Argus** Boyer.

Biddulphia Argus Boyer, Proc. Acad. Nat. Sci. Phil. (1898), 469, Pl. 24, fig. 6. Schmidt's Atlas, Pl. 120, fig. 27, apparently represents an intermediate form.

Valve broadly elliptical, convex, with an elliptical depression at centre, which is encircled by from 10 to 12 short spines. Processes rather short and obtuse. Surface with reticulations hexagonal, about 3 in .01 mm. at the border and 5 in .01 mm. at the centre, from which they radiate in curved lines. L. of v. .165 mm.

Port Antonio, Jamaica.

Distinguished chiefly by the central spines and by the size of the reticulations. It approaches *B. Roperiana* Grev. and *B. Peruviana* Grun.

13. **Biddulphia Edwardsii** Febiger.

Biddulphia Edwardsii Febiger (MSS.).
Odontella Edwardsii (Feb.) Grun., Diat. Fr. Jos. Land, 5, Pl. 2, fig. 20; V. H. Syn. Pl. 100, figs. 9, 10.

Valve suborbicular or orbicular-lanceolate. Surface with puncta from 5 to 7 in .01 mm., radiating from centre and with numerous evenly distributed short spurs, by which adjacent frustules are united. One or two small spines usually occur near each side. Processes short, truncate or obtuse. The prickly surface, under low powers, somewhat resembles that of *B. turgida.* Connective zone with puncta in parallel lines.

L of v. .033 mm. to .105 mm.

Pacific coast. Occasional on the Atlantic coast.

Prof. H. L. Smith (*A. J. M.*, 4, p. 101) considers this form to be " a hirsute variety of *B. Roperiana* Grev." It is probably intermediate between *B. Roperiana* and *B. primordialis* Brun. In large specimens a hyaline ring is quite distinct in the connective zone, as mentioned by Brun in his description of the latter species (*Esp. Nouv.*, 13). See also under *B. polyacanthos* Brun, *l. c.*, p. 12.

14. Biddulphia Cookiana K. and S.

Biddulphia Cookiana K. and S., Torr. Bull. (1889), 73, Pl. 89, fig. 4.
Odontella Cookiana (K. and S.) De Toni.
Biddulphia tumida (E.) Roper? T. M. S. (1859), 15, Pl. 2, figs. 18, 19.

Roper gives as the synonymy of his species *Denticella tumida?* E. and *Odontella tumida* Kütz., and states that the form agrees with Ehrenberg's description of a valve from "Bermuda" [Nottingham]. Roper's figures and description appear to show the identity of his form with *B. Cookiana* K. and S., an examination of the "Old Well" deposit of Richmond showing a large number of specimens, the smaller of which illustrate the globose character of the valves.

Valve suborbicular or elliptical-lanceolate, convex, with processes tumid at the base and small and obtuse at the apex. Surface with radiating, unequal, hexagonal reticulations, about 4 in .01 mm. One or two stout spines are placed on each side near the margin. Connective zone with parallel rows of puncta about 7 in .01 mm.

L. of v. .105 mm.

Fossil in the Miocene deposits of the Atlantic coast.

15. Biddulphia interrupta Boyer.

Biddulphia interrupta Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 468, Pl. 24, fig. 2.

Valve elliptical, with small, rounded processes. Surface convex, finely punctate, the puncta about 10 in .01 mm., radiating in scattered lines from the centre, at which are three minute spines. About one-third of the distance from centre to processes, at each end, a hyaline band, produced by the interruption of puncta, crosses the valve transversely extending nearly to the sides. L of v. .112 mm.

Campeachy Bay. Rare.

16. Biddulphia granulata Roper.

Biddulphia granulata Roper, T. M. S. (1859), 13, Pl. 1, figs. 10, 11, Pl. 2, fig. 12.

This form has been identified with *Denticella turgida* Ehr. = *Odontella turgida* Kütz. = *Biddulphia turgida* (Ehr.) Ralfs (not Wm. Sm.), and it appears to be equivalent, in outline at least, to *Denticella dubia* Bail. "It is impossible," as Roper remarks, "to speak with certainty."

Valve elliptical-lanceolate. Surface convex with diagonal rows of fine puncta about 12 in .01 mm., and with sparsely scattered small spurs. Processes slightly inflated at the base, obtuse at the ends, which are curved outward toward alternate sides. Near each process and on opposite sides of the longitudinal axis is placed a long, stout spine, bent or curved inward near the middle. Connective zone with rows of diagonal puncta slightly smaller than those on the valve. L. of v. .108 mm.

Vera Cruz. Fossil in the Pleistocene clay from the Norfolk artesian well. Not common.

17. **Biddulphia seticulosa** Grun.

Biddulphia seticulosa Grun., V. H. Syn., Pl. 101, figs. 7, 8.
Denticella seticulosa (Grun.) De Toni.

Valve elliptical, acuminate at the ends, from which arise horn-like, obtuse processes. Surface of valve divided longitudinally by an indefinite, irregular line which does not reach the extremities and from which proceed the rows of puncta parallel at the middle, but radiating toward the ends. Minute spurs are scattered over the surface in addition to longer spines, indefinite in number, but usually three to six on each side near the margin. Puncta, about 6 in .01 mm., are arranged in vertical rows on connective zone and also extend almost to the end of processes.

L. of v. .198 mm. Width of v. .082 mm. L. of frustule .072 mm.

Fossil in the Petersburg, Va., deposit.

Van Heurck considers this as probably a form of *Triceratium tridactylum* Brightw. (= *Biddulphia spinosa* (Bail.)), and as probably near *B. reticulata* var. *b*. Roper. See remarks under *B. spinosa.*

18. **Biddulphia spinosa** (Bail.).

Triceratium spinosum Bail., Sil. Jour. (1844), 139, Pl. 3, fig. 12; Schmidt, Pl. 87, figs. 2, 3, 4, 5.
Triceratium tridactylum Brightw.
Triceratium armatum Roper.
Triceratium setigerum Bail.
Triceratium serratum Wallich.
Not *Biddulphia spinosa* Grev. = *Denticella spinosa* (Grev.) Grun.

Schmidt (*Atlas*, Pl. 87) considers this form equivalent to *Triceratium Pileus* Ehr. (*Mikrogeologie*, Pl. 19, fig. 18), but Ehrenberg's figure certainly does not represent this form. Grunow states that *Triceratium spinosum* is a triangular form of *Biddulphia* *granulata* Roper. Specimens in my collection from Vera Cruz and the Norfolk artesian well of *Biddulphia granulata* have a finer reticulation than *Biddulphia spinosa*, but the two forms are quite similar. Prof. Smith attributes Bailey's *Triceratium setigerum* to *Triceratium comptum* Ehr., but Bailey's figure appears to represent a form nearer *spinosum*.

Valve triangular or quadrangular, with straight or concave sides. Angles produced into horn-like, obtuse processes. Surface convex, reticulated, the cells hexagonal, 3 to 5 in .01 mm. at centre, and slightly smaller toward the angles. At intervals of three or four cells small spurs usually occur giving a prickly appearance to the valve. Two to six or rarely more stout spines, in length about one-third to one-half the width of valve, and often forked at the ends in perfect specimens, are placed at unequal distances from the angles, two on each side, if of the usual number. In fossil forms most if not all of the spines are frequently broken off. In zonal view, the valve, as Bailey remarks, is constricted beneath the processes. The reticulations of the connective zone are similar to those of valve. L. of side .013–.156 mm. L. of frustule occasionally reaching .201 mm.

The dove-tailing of the lateral margins of the connecting zone at the angles, as described by Wallich in reference to *Triceratium serratum*, is well exhibited also in triangular forms in my collection from Yucatan. It is, however, merely the " postage stamp " fracture of the corners of the valve and is not always as regular as shown by Wallich.

West coast of Florida; Campeachy Bay; Yucatan.

Fossil in the Miocene deposits of the Atlantic coast and the St. Augustine artesian well.

19. **Biddulphia Rhombus** (Ehr.) Wm. Sm.

Biddulphia Rhombus (Ehr.) Wm. Sm., Brit. Diat., *2*, 49, Pl. 45, fig. 320, Pl. 61, fig. 320; Schmidt, Pl. 120, figs. 11-13.
Zygoceros Rhombus Ehr.
Denticella Rhombus Ehr.
Triceratium Biddulphia Heib.
Triceratium striolatum Ehr.
Triceratium membranaceum Brightw.

Valve orbicular-rhomboidal with produced ends, or triangular with convex sides. Surface convex, with fine hexagonal reticulations from 7 to 9 in .01 mm., which are irregular on an elliptical or triangular central part, but which radiate thence to the margins and continue nearly to the ends of processes. Scattered over the surface are minute spurs. Processes small, short and obtuse. Near the convex margins strong, short spines occur, usually three on each side near the middle and two additional ones next each process. L. of v. .165 mm. W. of v. .112 mm.

The triangular form (var. *trigona* Cleve) differs apparently only in outline. The reticulations are not always radiate. In a specimen from an artesian well at Harvey Cedars, N. J., they occur in short, decussate, intermediate rows.

Common along the Atlantic coast. Fossil in the Miocene and later deposits of the Eastern States.

20. Biddulphia suborbicularis Grun.

Biddulphia suborbicularis Grun., V. H. Syn., Pl. 100, figs. 15, 16.
Biddulphia angulata A. S., Schmidt, Pl. 141, figs. 7, 8.
Denticella? suborbicularis (Grun.) De Toni.
Odontella angulata (A. S.) De Toni.

Valve suborbicular, frequently with several irregular, angular projections. Processes frequently unequal, inflated at the base and truncate. Surface elevated half-way between the processes and centre, at which a depression occurs, with reticulations from 5 to 8 in .01 mm., increasing in size toward the circumference and radiating in slightly undulating lines. Two, rarely three or four, stout spines are placed obliquely opposite half-way between centre and circumference. L. of v. .089 mm.

Fossil in the Nottingham deposit.

21. Biddulphia Smithii (Ralfs.) V. H.

Biddulphia Smithii (Ralfs.) V. H. Syn., 207.
Eupodiscus radiatus Wm. Sm. = *Biddulphia radiatus* = *Eupodiscus velatus* Grev.
Cerataulus Smithii Ralfs., Schmidt, Pl. 116, figs. 5, 6.
Cerataulus (*Odontella*) *Smithii* Ralfs., V. H. Syn., Pl. 105, figs. 1, 2
Zygoceros hemitropus L. W. Bail.
Biddulphia hemitropa L. W. Bail.
Not *Auliscus radiatus* (Ehr.) Jan. and Rab.

Valve orbicular, convex. Surface with reticulations 5 in. .01 mm., radiating from the centre and smaller near the processes which are tapering and truncate. A short spine is usually found on each side near the circumference about half-way between the processes. Connective zone narrow, with vertical rows of puncta, 12 in .01 mm. Diam. of v. .059 mm.

Charleston, S. C., and southward. Common at Vera Cruz, Honduras and Campeachy Bay.

22. **Biddulphia Favus** (Ehr.) V. H.

Biddulphia Favus (Ehr.) V. H. Syn., 208, Pl. 107, figs. 1, 2, 3, 4.
Triceratium Favus Ehr., Schmidt, Pl. 82, figs. 1, 2, 3, 4.
Triceratium comptum Ehr.
Triceratium muricatum Brightw.
Triceratium megastomum Brightw.
Triceratium scitulum Brightw.
Triceratium fimbriatum Wallich.
Triceratium orientale Bail. and Harv.
Triceratium cuspidatum Janisch.
Amphitetras cuspidata L. W. Bail.

Valve three or four-angled, with straight or slightly concave or convex sides. Angles obtuse, occasionally somewhat constricted, each with an obtuse, horn-like process. Surface slightly convex, divided into large hexagonal cells. Inner or lower surface of valve finely punctate, the puncta radiating in undulating rows from the centre and extending to processes, about 18 in .01 mm. in the common forms. Zonal view quadrangluar, the connective zone marked with puncta in quincunxes. Frustules attached by alternate angles zigzag in a chain, usually found free. L. of s. averages in the common forms .15 mm.

Common in the triangular form along the Atlantic coast, more especially southward, where it is associated with the smaller triangular and quadrangular forms known as *Triceratium scitulum.* Rare on the Pacific coast in the quadrate form. Fossil in the Eastern States in deposits later than the Miocene.

23. **Biddulphia grandis** (Br.).

Triceratium grande Br., M. J. (1853), 250, Pl. 4, fig. 8; var. *pentagona* Grun., Schmidt, Pl. 86; var. *septangulata* Kitton, Schmidt, Pl. 85, figs. 1, 2, Pl. 86, figs. 11, 12, 13.
Triceratium ponderosum Edwards, Lens, 2, 105.
Triceratium Favus septangulatum Kitton.
Triceratium Strabo, Schmidt, Pl. 86, figs. 6, 7.

Valve as in *B. Favus* but larger, varying from triangular to septangular, the sides occasionally reaching .281 mm. in length, while the puncta of the lower surface of the valve are frequently about 7 in .01 mm.

Colon. Fossil in the Miocene deposits of California.

24. **Biddulphia acuta** (Ehr.).

Triceratium acutum Ehr., V. H. Syn., Pl. 108, fig. 1.

The form known as *Triceratium acutum* (Ehr.) is sometimes confounded with acute forms of *Triceratium punctatum* Br.

Valve triangular, sides slightly convex and processes at the angles somewhat acute. Surface flat, reticulated, cells hexagonal, 2 in .01 mm. at the centre, 3 in .01 mm. at the border, not radiate. L. of s. .04 mm. to .122 mm.

Fossil in the Miocene deposits of the Eastern States.

It is possible that *B. grandis* and *B. acuta* may be considered as varieties of *B. Favus*. It is to be noted that *B. Favus* is recent, not occurring in the Miocene deposits, while *B. grandis* occurs fossil in California Miocene and recent in the south Atlantic.

25. **Biddulphia Robertsiana** (Grev.).

Triceratium Robertsianum Grev., M. M. J. (1863), 231, Pl. 9, fig. 9 (?); ib. (1886), Pl. 2, fig. 22; Schmidt, Pl. 83, figs. 2, 3, 4, 5, 6, 7.

Triceratium Robertsianum Grev. var. *macracantha* Grun., Schmidt, Pl. 82, figs. 14, 15.

Valve triangular or quadrangular, with convex sides. Surface convex with hexagonal reticulations averaging .008 mm. in diameter, scarcely longer toward the sides. Angles very slightly produced, with elevated, obtuse processes. Inner plate of valve finely but distinctly punctate as in *B. Favus*. One or more short, stout spines are frequently found on each side near the border. W. of v. .148 mm.

Gulf of Mexico (Gründler in Schmidt); Pacific soundings, 20° 10′ N., 158° 14′ W., 2507 fathoms. Rare.

26. **Biddulphia Campeachiana** (Grun.).

Triceratium Campeachianum Grun., M. M. J. (1874), 319; Schmidt, Pl. 78, figs. 18, 19, 20.

Amphipentas Campeachiana (Grun.) De Toni.

Valve pentagonal with sides tumid at the middle, producing a decagonal outline. Processes at the angles conical, obtuse. Surface almost flat, reticulated, the cells hexagonal, nearly equal, 2 in .01 mm. The inner plate of valve is punctate as in *B. Favus*. W. of v. .072 mm. to .125 mm.

Campeachy Bay.

27. **Biddulphia dubia** (Br.) Cleve.

Biddulphia dubia (Br.) Cleve. "Vega," 508.

Triceratium dubium Br., T. M. S. (1859), 180, Pl. 9, fig. 12; Schmidt, Pl. 78, figs. 26–30.

Triceratium bullosum Witt.

Triceratium (*or Biddulphia*) *bicorne* Cleve, Diat. West Ind., 17, Pl. 5, fig. 30; Schmidt, Pl. 78, figs. 24, 25.

Amphitetras bicornis (Cleve) De Toni.

Valve rhombic-lanceolate, the ends produced into obtuse processes, while the sides are turgid and extended into rounded projections. Abnormal forms are frequent. Surface reticulate, the unequal, usually hexagonal cells averaging .005 mm. in diameter. Within the cells indistinct granulations are seen. L. of v. .075 mm.

Atlantic coast, southward, not common; California (Cleve).

28. **Biddulphia reticulata** Roper.

Biddulphia reticulata Roper, T. M. S. (1859), 14, Pl. 2, figs. 13, 14, 15; Schmidt, Pl. 78. figs. 21–23, Pl. 121, figs. 11–15.
Odontella? reticulata (Roper) De Toni.

Valve elliptical-lanceolate or rhombic with turgid sides. Processes conical and obtuse. Surface coarsely reticulate, the reticulations 1 to 1½ in .01 mm., the inner layer with puncta from 6 to 9 in .01 mm., resembling those of *B. Favus.* Connective zone with parallel rows of puncta about 5 in .01 mm. L. of v. .122 mm.

Honduras; Pacific coast.

29. **Biddulphia Peruviana** Grun.

Biddulphia (*tumida* Roper, var.?) *Peruviana* Grun., V. H. Syn., Pl. 101, figs. 2, 3.
Biddulphia tumida var.? *Peruviana* (Grun.) De Toni. (Appears to differ from *B. tumida* (Ehr.?) Roper in the greater prominence of the hyaline band.)

Valve orbicular-rhomboidal or elliptical-lanceolate, convex, with depressions at the centre and toward the processes, slightly constricted above the connective zone and surrounded by a narrow, apparently hyaline, band. Processes swelling near the base and small and obtuse at the apex. Surface with unequal, hexagonal reticulations, from 2 to 4 in .01 mm., extending to the apices of the processes on which they are smaller. The inner plate or floor of cell wall is distinctly punctate. Two or three strong spines are usually found on each side near the margin. Connective zone with diagonal reticulations about 7 in .01 mm. L. of v. 138 mm.

Peruvian guano (Grun.); Callao, Peru. Possibly to be met with northward.

30. **Biddulphia Keeleyi** Boyer.

Biddulphia Keeleyi Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 469, Pl. 24, fig. 4.

Valve broadly rhombic-elliptical, rounded at the ends. Surface slightly convex, without depression, with unequal, hexagonal reticulations, about 2 in .01 mm.; puncta within the reticulations about 8 in .01 mm. Three stout spines are placed on each side near the margin. Processes inflated at the base, small at the apex and placed, not at the ends of the valve, but obliquely opposite, near the ends. L. of v. .148 mm.

U. S. S. "Tuscarora," soundings, Lat. 36° 12′ N., Long. 123° 11′ W., 1605 fathoms. Coast of California (F. J. Keeley); Monterey Bay (J. A. Shulze). Rare.

31. **Biddulphia consimilis** (Grun.).

Triceratium consimile Grun., V. H. Syn., Pl. 108, fig. 2; Schmidt, Pl. 84, figs. 13, 14.

Valve triangular, with sides slightly convex. Angles rounded, filled with the prominent cylindrical, short and rounded processes. Surface nearly flat, with reticulations which average .008 mm. in diam., varying from triangular to hexagonal, with unequal sides.

The inner plate of the valve is rather coarsely punctate, the puncta being about 5 in .01 mm.

L. of s. .120 mm. to .198 mm.

Campeachy Bay. Fossil in Santa Monica deposit.

32. **Biddulphia convexiuscula** (Grun.).

Triceratium convexiusculum Grun., Schmidt, Pl. 151, figs. 5, 6.

Valve triangular, sides convex. Angles rounded, with short, truncate processes. Surface convex, with puncta about 7 in .01 mm., radiating from the centre. On one or both sides of each angle is a short spine. On the connective zone the puncta are in diagonal rows. L. of s. averages .052 mm.

The general appearance is that of a three-sided form of *Biddulphia lævis*, from which it differs in the puncta of the connective zone which are usually larger in the former.

Campeachy Bay; Honduras; stomachs of fish from coast of South Carolina; Tampa Bay, Fla.

33. **Biddulphia orbiculata** (Shadb.).

Triceratium orbiculatum Shadb., T. M. S. (1854), 14, Pl. 1, fig. 6.
Triceratium (orbiculatum Shadb. var.) *elongatum* Grun.
Triceratium Shadboltianum Grev., Schmidt, Pl. 80, fig. 18-20.
Triceratium gibbosum Bail and Har., Schmidt, Pl. 80, fig. 13.
Triceratium gibbosum var. *elongatum* Grun., Schmidt, Pl. 80, fig. 21.
Lampriscus Kittoni A. S., Schmidt, Pl. 80, fig. 11.
Biddulphia crenulata W. C. Walker.

Valve triangular, with convex sides, or orbicular. Outline entire or crenulate. Processes three or more, large, considerably elevated and truncate. Surface slightly convex, with puncta radiating from the centre, about 11 in .01 mm., becoming much finer at the apex of the processes. A short strong spine is frequently found quite near one or more of the processes. Connective zone occasionally much elongated and annulate, with puncta in longitudinal rows. Diam. averages .092 mm.

Honduras; Colon.

Both Greville and Ralfs separate *Triceratium orbiculatum* Shadb. from the form described under that name by Brightwell and named by Greville *T. Shadboltianum* on account of the absence of spines in the former. In material from Honduras many variations occur in forms which, I believe, belong to one species. In some valves no spines are seen, in others one or more may be noticed, and occasionally two spines are found near one process. Some valves are quite orbicular and occasionally somewhat elliptical, while others, chiefly the smaller, are more nearly triangular. It is in the smaller, triangular valves that the great extension of the connective zone is seen, as in the form named *T. gibbosum* var. *elongatum* Grun. Owing to the incomplete description by Bailey and Harvey, who state that forms from Tahiti have " a surface as in *T. Wilkesii*," and to the uncertain figure, it is difficult to reach an absolute conclusion as regards the identity of their form with the present species. The description above given is from valves found at Honduras, where occur also forms with three or four processes and with crenulate margins, as in *Lampriscus Kittoni*, but otherwise similar to the triangular forms.

34. Biddulphia verrucosa Boyer.

Biddulphia verrucosa Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 468, Pl. 24, fig. 5.

Valve suborbicular, convex. Processes very large, cylindrical, truncate. Surface coarsely reticulate, the reticulations unequal, irregular, about 2 in .01 mm. Within the reticulations are coarse puncta about 3 in .01 mm.

L. of v. .138 mm.

Fossil at Redondo Beach. Very rare.

This form, which approaches the *Cerataulus* group, is distinguished by the encrusted or warty appearance of the surface.

35. **Biddulphia turgida** (Ehr.) Wm. Sm.

Biddulphia turgida (Ehr.) Wm. Sm., Brit. Diat., *2*, 50, Pl. 62, fig. 384.
Cerataulus turgidus Ehr. Schmidt, Pl. 116, figs. 1–3, Pl. 115, figs. 12–14.
Odontella turgida Wm. Sm. (?), De Toni.

Valve elliptical, convex. Surface with undulating rows of fine puncta about 9 in .01 mm., and with numerous minute spurs at irregular intervals. Processes very large, cylindrical, truncate, placed obliquely opposite near the ends, and, owing to the torsion of the frustule, directed sideways. Between the processes two stout spines, frequently forked at the ends in perfect specimens, are placed, one on each side, obliquely opposite, near the border. Around the margin a row of very short spines frequently occurs. L. of v. .132 mm.

In zonal view the frustule appears subglobose and twisted on its longitudinal axis in such a way that the edges of the valves appear undulating and the connective zone "sigmoid." Puncta on the connective zone in diagonal rows about 11 in .01 mm. In var. *multispina* Grun. the two large spines are usually replaced by from two to four shorter ones on each side, and numerous short, stout spines are found on the circumference, but variations occur. (*Biddulphia turgida* (Ehr.) Ralfs, *Denticella turgida* Ehr. and *Odontella turgida* Kütz. are not equivalent. They are, possibly, forms of *Biddulphia granulata* Roper.)

Atlantic and Pacific coasts. Fossil in the deposits of California, Atlantic City and Bridgeton, N. J.

In the Californian deposits numerous variations occur. The form figured in Schmidt's *Atlas*, Pl. 115, fig. 15, under the name of *Cerataulus Johnsonianus* var. appears to me to approach nearer to *turgida* than to Greville's form. Both it and var. *multispina* Grun. are not uncommon in the Redondo Beach deposit.

36. **Biddulphia Californica** (A. S.).

Cerataulus Californica A. S., Schmidt, Pl. 115, figs. 2, 3, 4.

Valve broadly ovate-elliptical or suborbicular, with very short, truncate, hyaline processes. Surface somewhat flat, studded with minute spurs, finely reticulated, the reticulations hexagonal, about 8 in .01 mm. Border of valve with a row of small spurs. Two very short spines are usually found on each side near the border.

L. of v. .198 mm.

Numerous forms are found in the Redondo Beach deposit, which merely differ in outline and in the number and prominence of the spines which are sometimes absent.

Fossil on the Pacific coast.

37. **Biddulphia ovalis** (A. S.).

Cerataulus ovalis A. S., Schmidt, Pl. 115, figs. 5, 6, 7.

Valve broadly elliptical with short, truncate processes. Surface flat, with fine, hexagonal reticulations about 8 in .01 mm., without spines or spurs. L. of v. .039 mm.

Fossil at Redondo Beach, Cal., and Weymouth, N. J.

38. **Biddulphia lævis** Ehr.

Biddulphia lævis Ehr., Berl. Akad. (1843), 122.
Cerataulus lævis (Ehr.) Ralfs, Prit., 847.
Cerataulus lævis (Ehr.) Schmidt, Pl. 116, figs. 13, 14, 15.
Denticella lævis Ehr.
Cerataulus lævis thermalis Grun., Schmidt, Pl. 116, figs. 8–11.
Isthmia polymorpha Mont., Kütz. Bacill., 138.
Odontella polymorpha Kütz.
Cerataulus thermalis (Menengh.) Ralfs.
Pleurosira thermalis Menengh.
Melosira thermalis Menengh.
? Gallionella ? —— Bail., Sil. Jour. (1842), 104, Pl. 2, fig. 8.
(*B. subæqua* K.? and *B. obtusa* (K.) Grun., of some authors, have been confounded with *B. lævis* Ehr.)

Valve suborbicular or occasionally subtriangular, convex, with short, truncate processes. Surface with fine puncta, averaging 13 in .01 mm., which radiate in more or less curved lines from the centre. Two small spines are placed obliquely opposite about half the radius from the centre. Entire surface apparently covered with very minute spur-like elevations which are usually invisible under ordinary illumination. The puncta on the connective zone are slightly smaller than those on the valve. L. of v. .066 mm.

Generally distributed along the Atlantic and Pacific coasts. Abundant at Port Townsend, Wash. Fossil in salt marsh deposits of Kansas, Utah, Nebraska and Michigan. Also occurs in fresh-water lakes.

39. **Biddulphia Thumii** (A. S.).

Cerataulus Thumii A. S., Schmidt, Pl. 115, fig. 1.
Cerataulus Hungaricus Pant.? Foss. Bacill. Ung., *2*, Pl. 26, fig. 375?

Valve suborbicular, with large, short, truncate processes. Surface with fine puncta confused and scattered at the centre, from which they radiate in undulating lines toward the processes and the circumference where they average 11 in .01 mm. In large specimens the surface slightly undulates between the processes. L. of v. .204 mm.

Fossil at Redondo Beach, Cal. Rare.

The Californian form is not distinct, I think, from the Hungarian, except that in the latter, in the few specimens I have seen, the puncta are larger and more confused.

40. Biddulphia Circinus (Bail.) V. H.

Biddulphia Circinus (Bail.) V. H., Diat., fig. 200.
Zygoceros Circinus Bail., N. Sp., Pl., figs. 19, 20; V. H. Syn , Pl. 105, fig. 13.

Valve elliptical, rising into the form of a truncated cone, from the top of which, at each end, extends a long, inwardly bent spine. A few much smaller, intermediate spines are scattered over the surface which is slightly rugose and punctate, the puncta more or less radiate, averaging 7 in .01 mm. Processes wanting. Connective zone well developed, with fine puncta, from 9 to 13 in .01 mm., in longitudinal rows. L. of v. .083 mm.

Fossil at Richmond (Bail.); Santa Monica (Grun.). Rare.

41. Biddulphia quadricornis (Grun.).

Zygoceros quadricornis Grun., V. H. Syn., Pl. 105, figs. 5-7.

Valve orbicular or suborbicular, having four spines which rise from the four corners of the summit of the truncated cone. Otherwise apparently as in *B. Circinus*, of which it is, probably, a variety.

Fossil at Nottingham (Grun.).

42. Biddulphia Balæna (Ehr.) Br.

Biddulphia Balæna (Ehr.) Br., M. M. J. (1859), 181, Pl. 9, fig. 15; Schmidt, Pl. 121, figs. 5, 6.
Zygoceros Balæna Ehr., Mik., Pl. 35, A, 33, fig. 17.
Zygoceros radiatus Bail.
Triceratium formosum Br., and *Triceratium formosum pentagonalis* A. S., Schmidt, Pl. 79, figs. 2, 3, 4.

Valve elliptical or angular, in zonal view quadrangular. Surface flat or somewhat concave, slightly elevated at the ends or angles, finely reticulate, the hexagonal reticulations about 5 to 8 in .01 mm., radiating from the centre in the smaller valves, but in the larger, elliptical forms, transverse in the middle. Connective zone with parallel rows of puncta, smaller than those on the valve, about 5 in .01 mm. L. of v. in elliptical form .231 mm.

Near *Biddulphia arctica* (Br.), but with much finer reticulations· Cleve states (*Arct. Diat.*, 15) that these forms are not specifically distinct,' as he has seen a transitional form between *Zygoceros Balæna* E. and *Triceratium arcticum* Br. I have noticed a triangular form in material from McCormack Bay, Greenland. The elliptical form of the same locality shows markings closely resembling those of *B. arctica*, each reticulation containing 3 or 4 puncta on the upper surface of valve.

Greenland (Cleve); Nova Scotia; McCormack Bay, Greenland; fossil at San Luis Obispo, Cal. (J. D. Cox); Nottingham (Br.).

43. **Biddulphia arctica** (Br.).

Triceratium arcticum Br., M. M. J. (1853), 250, Pl. 4, figs. 10, 11; Schmidt, Pl. 79, figs. 5–13, Pl. 81, figs. 3, 4, Pl. 94, figs. 1, 2, 3.
Triceratium Wilkesii var. Bail. and Harv.
Amphitetras Wilkesii Bail. and Harv.
Trigonium arcticum Cleve.

Valve elliptical (?) or angular. Sides straight, convex or concave, with rounded angles which are scarcely elevated. Surface of valve rather coarsely reticulate or cellular, the cells irregularly pentagonal or hexagonal, radiating from centre and usually slightly larger near the semi-radius, distinctly punctate near the perimeter. Angles finely punctate, the rows of puncta slightly converging toward the apex where they are smaller. Connective zone with coarse puncta in longitudinal rows. Zonal view usually quadrangular but occasionally showing the surface much elevated. A species quite variable in size and outline.

By careful examination a fine hexagonal punctation may be seen around the margin of the cells and upon the *upper* surface of the valve, resembling the arrangement in certain forms of *Coscinodiscus* (see text of Pl. 165 of Schmidt's *Atlas*).

Abundant on the Pacific coast; Campeachy Bay (Grun.); fossil in California and very rarely at Asbury Park, N. J.

The following are considered varieties:

B. arctica Campeachiana (Grun.) = *Triceratium arcticum* forma *Campeachiana* Grun., triangular, with straight sides.

B. arctica Californica (Grun.) = *Triceratium arcticum* var. *Californica* Grun., with produced angles, concave sides and hyaline centre. Occurs three- and four-sided.

B. arctica Kerguelensis (Grun.) = *Triceratium arctica* var.

Kerguelensis Grun., differing from *Californica* in not having the angles produced.

B. arctica Montereyi (Br.) = *Triceratium Montereyi* Br., differs from the type merely in the elevation of the surface which is quite pronounced in certain specimens, but differs in valves of the same frustule. In specimens in my collection frustules show one valve with no elevation and the other with a very marked central protuberance. In another frustule both valves are much elevated at the centre as in those described by Grove and Stout (*Diat. Oamaru*, Pl. 11, fig. 25).

B. arctica quadrangularis (Grev.) = *Triceratium quadrangulare* Grev., which apparently differs only in a slight constriction of the angles from other quadrate forms.

B. arctica pentagona = *Triceratium arcticum*, forma *pentagona*, from Redondo Beach.

B. arctica sexangulata = *Triceratium arcticum sexangulatum*, a very beautiful six-sided form occurring in a sounding from the Pacific, west of California (not *T. sexangulatum* Grev.) (Coll. J. A. Shulze).

According to Van Heurck (*Diat.*, p. 61), the form known as *Triceratium formosum* Br. is equivalent to *Biddulphia Balœna.* The pentagonal form shows puncta within the reticulations similar to those in the type form of *B. arctica.* Owing to the numerous variations of *Balœna* and *arctica*, it becomes difficult to separate them satisfactorily.

44. **Biddulphia Heilpriniana** (K. and S.).

Triceratium Heilprinianum (K. and. S.) Torr. Bull. (1889), 208, Pl. 93, fig. 3.

Valve triangular, sides straight or but slightly convex or concave. Angles elevated into conical, obtuse processes to a height about equal to one-eighth of the width of valve. Surface, with its central portion having about the same elevation as the angles and flattened at the top, with rounded, unequal puncta, about 4 in .01 mm., and extending to the summit of the processes where they are slightly smaller. L. of v. .064 to .135 mm.

Atlantic City artesian well. Rare.

45. Biddulphia vesiculosa (Ag.).

Diatoma vesiculosum Ag., Sys., 7 (1824).
Isthmia vesiculosa Ag., Consp. Crit., 55.
Amphitetras antediluviana Ehr., Berl. Akad. (1839), Kütz. Bacill., 135, Pl. 19, fig. 3, Pl. 29, fig. 86.
Amphitetras crux Br.
Triceratium antediluvianum Grun.
Biddulphia antediluviana (Ehr.) V. H. Syn., 207, Pl. 109, figs. 4, 5, Pl. 100, figs. 3, 4.

Valve quadrangular, or rarely pentagonal, with more or less concave sides and rounded angles. Processes very short and truncate, frequently unequal. Surface with coarse, rounded, quadrate or hexagonal reticulations, smaller at the centre from which they radiate, and averaging 3 in .01 mm., their walls often considerably thickened. The secondary layer is punctate, but the puncta, owing to the thickness of the cell walls, are difficult to see in most specimens. Ends of processes very minutely and indistinctly punctate. L. of s. .059 mm. to .115 mm.

Edgarton Harbor (Bail.); L. I. Sound (Lewis); St. Mary's river, Ga. (Lewis); Savannah (Lewis); Provincetown, Mass.; Port Townsend, Wash. Fossil at Asbury Park, N. J. A pentagonal form occurs fossil at Asbury Park, which is not the same as *Amphipentas alternans* Ehr.

46. Biddulphia decipiens Grun.

Biddulphia decipiens Grun., V. H. Syn., Pl. 100, figs. 3, 4.
Amphitetras minuta Grev., M. M. J. (1861), 77, Pl. 9, fig. 11 ?.
Amphitetras (*Biddulphia*) *alternans*, H. L. Smith, Christian, in "The Microscope" (1887), 67, fig., p. 113; Schmidt, Pl. 98, fig. 23 (without name).

The equivalence of *Amphitetras minuta* Grev., as doubtfully given by Van Heurck, is too uncertain to give priority to the name, as Greville, in both description and figure, omits any reference to processes, surface or spines. The processes are, however, frequently quite indefinite and the spines are more often broken off.

Valve rhomboidal with the sides turgid and produced, giving, therefore, a cruciform outline. Surface rising suddenly from near the margin into an ellipsoidal elevation, the major diameter of which is at right angles to the major axis of valve, with hexagonal reticulations, about 5 in .01 mm., at the centre, from which they radiate toward the processes and rounded angles of the sides where they are about 9 in .01 mm. Processes inflated at the base, small and obtuse. At the margin of the elevation, placed obliquely on each side, a strong spine projects.

L. of v. .059 mm. to .072 mm.

Fossil at Nottingham and Atlantic City.

47. **Biddulphia elegans** (Grev.).

Amphitetras elegans Grev., T. M. S. (1866), 9, Pl. 2, fig. 24.
Triceratium elegans (Grev.) Grun., V. H. Syn., Pl. 109, fig. 1; Schmidt, Pl. 99, figs. 10–13.

Valve quadrangular, with sides slightly concave. Angles with short, cylindrical processes. Surface depressed at the centre, with rounded cells, averaging 5 in .01 mm., radiating toward the angles where they are smaller and more crowded. The absence of reticulation half-way between the centre and processes frequently produces, under low powers, the appearance of an inscribed square.

L. of s. .092 mm.

Campeachy Bay (Schmidt); fossil at Monterey, Santa Monica and Redondo Beach, Cal.

48. **Biddulphia biquadrata** (Jan.).

Triceratium biquadratum Jan., Schmidt, Pl. 98, figs. 4, 5, 6.

Valve quadrangular with slightly concave sides. Angles rounded, with short, truncate processes. Surface with coarse reticulations, about 2½ in .01 mm., the walls of which correspond, for the most part, with the meshes of a coarser network which is unequally but symmetrically distributed, producing, by its peculiar arrangement, the appearance, under low powers, of an inscribed square.

L. of s. .112 mm.

The chief distinction between this form and *B. Pentacrinus* is in the greater coarseness of the reticulations in the former and the closer correspondence of its anastomosing network and the cell walls. It is, apparently, intermediate between *B. vesiculosa* and *B. Pentacrinus*.

Yucatan; Gulf of California.

49. **Biddulphia Pentacrinus** (Ehr.).

Amphipentas Pentacrinus Ehr., Berl. Akad. (1840), 10; Mik., Pl. 19, fig. 59; Kütz., Bacill., 136, Pl. 29, fig. 92.
Triceratium Pentacrinus (Ehr.) Wall., Schmidt, Pl. 98, figs. 7-13, 18.
Amphipentas alternans Ehr.
Amphitetras arisata Shadb.
Amphitetras ornata Shadb.
Triceratium quadrinotatum A. S., Schmidt, Pl. 152, fig. 31.

Valve quadrangular or pentagonal, with concave sides. Angles obtuse with short, truncated processes. Surface nearly flat, with hexagonal reticulations, 5 to 7 in .01 mm., radiating from the centre. The walls of the reticulations being more robust in some parts than in others, there is produced an appearance of a coarse network of various design extending over the entire surface. A minute spur-like projection is frequently found between each angle and near the circumference in both the quadrangular and pentagonal forms.

L. of s. .092 mm.

Atlantic and Pacific coasts More abundant in Gulf of Mexico and southward.

50. **Biddulphia Kainii** (Schultze).

Triceratium Kainii Schultze, K. and S., Bull. Torr. Cl. (1889). 76, Pl. 89, fig. 5, Pl. 92, fig. 3.
Triceratium Kainii constrictum Schultze, K. and S., *l. c.*
Triceratium multifrons Brun., Diat. foss. Jap., 63, Pl. 6, fig. 2.

Valve triangular or quadrangular, with sides varying from straight to deeply convex. Angles more or less cuneate, obtuse, rarely constricted, separated from the other part of valve by strong costæ which are equidistant between centre and apices. Surface slightly convex, with puncta about 5 in .01 mm., radiating from a hyaline centre, or, occasionally, scattered L of s. .056 to .138 mm.

Fossil in the Miocene deposits of the Eastern States. A quadrate form has been found by Mr. John A. Shulze in material from Mays Landing artesian well, N. J.

51. **Biddulphia Tabellarium** (Br.).

Triceratium Tabellarium Br., M. M. J. (1856), 275, Pl. 17, fig, 15; Schmidt, Pl. 77, figs. 1–9.
Triceratium Tabellarium diplostictum Grun., Schmidt, Pl. 77, figs. 1, 2.
Triceratium Johnsonii Ralfs., Prit., 854.
Triceratium venulosum Grev.
Triceratium brevinervium Grev.
Triceratium pallidum Grev.

Valve triangular, with somewhat acute angles and straight or slightly convex sides having an indented or scalloped appearance caused by the extension inwards, for a short distance, of several costæ which are usually curved at the extremities. Surface slightly elevated at the centre and at the angles, with a few scattered puncta more numerous at the angles. L. of s. .06 mm. to .14 mm.

In certain specimens indistinct lines radiate from the centre and in conjection with two of the partial costæ from each side form a three-lobed figure. In most of the specimens each of the angles is distinctly separated from the centre by an irregular line.

Campeachy Bay; Honduras.

52. **Biddulphia alternans** (Bail.) V. H.

Biddulphia alternans V. H. Syn., 208, Pl. 113, figs. 4–7.
Triceratium alternans Bail., M. Obs., 40; Sil. Jour. (1845), Pl. 4, fig. 25; *ib.*, M. Ex. S., fig. 55, 56; Schmidt, Pl. 78, figs. 9–17.
Triceratium sp.? Bail., Sil. Jour. (1845), 336.
Triceratium variabile Br.

Valve triangular or rarely quadrangular, with sides straight or, usually, somewhat unevenly concave. Angles obtuse, slightly elevated, separated from central portion by costate lines. Central part hexagonal in outline, marked by several lines resembling costæ which extend indefinitely from the periphery in various directions, usually toward the centre. Surface with puncta of irregular shape, larger at the centre, about 5 in .01 mm., and diminishing toward the apices of the angles on which they are usually arranged in rows about 8 in .01 mm. Zonal view quadrate, angles not prolonged. Connective zone narrow. L. of s. .05 mm.

Abnormal variations occur with unequal sides.

Common along the Atlantic coast, especially in æstuaries, but not abundant; Puget Sound; fossil in rice fields of Georgia and California (Bail.), and in the Miocene deposits of the Eastern States and of California; Pleistocene clay, Harvey Cedars, N. J.

53. **Biddulphia trisulca** (Bail.).

Triceratium trisulcum Bail., (Ms.) in Prit., 854; Schmidt, Pl. 78, figs. 5–8, Pl. 112, figs. 17, 18.
Triceratium validum Grun., Schmidt, Pl. 94, fig. 5.

Valve triangular with concave sides and rounded angles which are elevated into large, globose processes. Surface with rounded, scattered puncta averaging 1 in .01 mm. Angles with indefinitely angular reticulations about 4 in .01 mm. Connective zone with puncta similar to those on the surface of valve. In one specimen observed, from Redondo Beach, in a continuation of an unusually well-developed connective zone overlapping one valve, the punctation assumed the character of large hexagonal reticulations about 2½ in .01 mm. L. of s. averages .15 mm.

Triceratium tumidum Grev. from Barbadoes, is very near this form.

Campeachy Bay. Fossil at Redondo Beach, Cal.

54. **Biddulphia costulata** (Grun.).

Triceratium tumidum Grev. var. *costulata* Grun ; Schmidt, Pl. 78, fig. 1, Pl. 88, fig. 17.

Valve triangular with straight or slightly concave sides and rounded angles, elevated into large, rounded processes. Surface as in *B. trisulca*, except that the puncta on the angles in the specimens observed are about 9 in .01 mm. Partial costæ, two to four on each side, extend inwards for varying distances from the perimeter. L. of s. 148 mm.

Fossil at Redondo Beach, Cal. Rare.

55. **Biddulphia condecora** (Ehr.).

Triceratium condecorum Ehr., Berl. Akad. (1844), 272; Schmidt, Pl. 76, fig. 28 (not 27). See remarks under *B. Americana*.

Valve triangular, or irregularly quadrilateral, with sides straight or but slightly convex or concave, and obtuse angles. Surface flat or slightly depressed toward the centre, having rounded puncta arranged in rows which radiate in undulating lines from the centre at which and on the margin they are slightly smaller, averaging 4 in .01 mm. L. of s. in type specimens .145 mm., but occasionally much smaller. Distinguished from *B. Americana* not only by the undulations of the rows of puncta, but also by their more pearly character. Specimens from Nottingham vary considerably in outline, several having but two angles and others having the form of a trapezium.

Fossil in the Miocene deposits of the Eastern States.

56. **Biddulphia** (?) **subrotundata** (A. S.).

Triceratium subrotundatum A. S., Schmidt, Pl. 93, fig. 1.

Valve orbicular-triangular, with very convex sides and indefinite angles. Surface flat, with subquadrate or hexagonal reticulations, radiating from the centre, where they are about 5 in .01 mm., and increasing to about 3 in .01 mm., but suddenly diminishing at the circumference. W. of v. .092 mm. Scarcely differing, except in outline, from *Coscinodiscus*.

Fossil at Nottingham. Very rare.

57. Biddulphia Americana (Ralfs).

Triceratium Americanum Ralfs, Prit., 855 ; Schmidt, Pl. 76, fig. 3 (?), 27 (see note).
Triceratium obtusum Ehr., Amer., 137 (?); Mik., Pl. 18, fig. 48 (?) (not 49?).
Triceratium Amblyoceros Br.
Triceratium obscurum Grev. forma *minor* A. S., Schmidt, Pl. 76, fig. 5.

This is a smaller form of *B. Americana.* I have noticed several intermediate variations which differ only in size and the convexity of the sides. Greville remarks of his species from Naparima that it resembles *T. condecorum,* except that "the radiating lines of puncta are perfectly straight"[5]

Valve triangular or occasionally irregularly quadrangular, with straight, convex or slightly concave sides and obtuse angles. Surface flat, having rounded or subquadrate reticulations, 3 or 4 in .01 mm., which in well-developed specimens radiate from the centre. At the margin the cells are smaller.

L. of s. averages .115 mm. Quite variable in size and outline.

Fossil in the Miocene deposits of the Eastern States.

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[5] Much confusion has arisen as to the distinction between *Triceratium Americanum* Ralfs and *Triceratium condecorum* Br., due partly to Ralfs' description of the former as equivalent to *T. Amblyoceros* Br., which in turn has been confused with *T. Amblyoceros* Ehr., and to the mistake made by Schmidt, as suggested by Gr. and St., in numbering figs. 27 and 28 in Pl. 76 of the Atlas, fig. 27 being *T. Americanum* and fig. 28 *condecorum.*

As *T. condecorum* is described as having undulating rows of granules, and as *T. Americanum* is said to resemble *T. arcticum* (see Roper), except in the angles, it may be as well to base the distinction between the two forms upon the undulations of the rows of radiating granules and upon the coarseness of the granules. It becomes, however, difficult to separate the smaller forms of the two species. Some specimens from Nottingham vary considerably in outline, some approaching *T. subrotundatum* A. S., while others are near *T. parallelum* Grev., as has been noticed by Grove and Sturt in forms from Oamaru.

Triceratium Americanum Ralfs is, probably, the same as *T. Amblyoceros* of Brightwell, but as Brightwell's form is not *T. Amblyoceros* of Ehrenberg, which in outline, if not in its centre, is probably *Actinoptychus Amblyoceros* A. S., Ralfs' name must stand as representing form fig. 27, Pl. 76, of the Atlas. De Toni unfortunately (p. 1396) gives *Actinoptychus Amblyoceros* A. S., Atlas, Pl. 1, fig. 25, as equivalent to forms of Pl. 76, figs. 3 and 28. A glance at fig. 25, Pl. 1, will show that it is entirely different from figs. 3 and 28 in Pl. 76. In fact, fig. 25, Pl. 1, is an *Actinoptychus* as given by Schmidt, while the other figures belong to *Triceratium. Triceratium Amblyoceros* E. and *T. Marylandicum* Br. may be abolished as forms of *Triceratia* and become *Actinoptychus Amblyoceros* (Ehr.) A. S., or, as appears to be necessary, *Schuettia Amblyoceros* (Ehr.) De Toni. It is probable that *T. obtusum* Ehr. as figured in Mik., Pl. 18, fig. 48, is the form under consideration, as there is apparently no other in the deposit, except possibly *T. interpunctatum,* to which it may be made to apply. By priority, therefore, the name would become *Biddulphia obtusa* (Ehr.), but on account of the uncertainty it may be as well to retain Ralfs' name.

58. Biddulphia Antillarum (Cleve).

Triceratium Antillarum Cleve, Diat. W. Ind., 16, Pl. 5, fig. 29; Schmidt, Pl. 99, fig. 14.
? *Triceratium punctatum* Br. formæ *hexagona* and *pentagona* Grun.; Schmidt, Pl, 81, figs. 6, 7.
Amphipentas Antillarum (Cleve) De Toni.
? *B.* (*Amphipentas*) *punctata* V. H., Diat., fig. 206.

Valve polygonal, with produced angles and concave sides. Surface slightly elevated at the centre, with puncta about 4 in .01 mm., rounded, radiating and extending to the ends of the angles, which appear like processes. L. of v. .115 mm. Very near certain forms of *B. Reticulum* (Ehr.), from which it apparently differs in the radiation of the puncta and in the form of the angles.

Campeachy Bay (Schmidt). Fossil at Redondo Beach, Cal., in the hexagonal form, but very rare.

59. Biddulphia interpunctata (Grun.).

Triceratium interpunctatum Grun., Schmidt, Pl. 76, fig. 7. According to De Toni (947), near *T. elegans* Grev., which in turn is said by Grev. to be *T. obtusum* Ehr., but I think the form is quite distinct.

Valve triangular, sides straight, and angles rounded. Surface flat, having rounded puncta nearly equal, about 3 in .01 mm., with here and there at intervals much smaller puncta.

L. of s. .075 mm. to .115 mm.

A form apparently quite constant. Near *B. Americana* Ralfs, from which it may be distinguished not only by the interpunctation, but also by the large, round and scattered puncta. Under low powers its color is blue.

Fossil in the Miocene deposits of the Eastern States.

60. Biddulphia hebetata (Grun.).

Triceratium irregulare var. *hebetata* Grun., V. H. Syn., Pl. 111, fig. 10.
Triceratium impar A. S., Schmidt, Pl. 151, figs. 31–34.

It is quite difficult to separate *Triceratium impar* A. S. from certain forms of *B. Americana* and from the present form, which is quite common in the Petersburg deposit. The peculiarity of the angles, however, appears to be sufficient to separate it from *T. irregulare* Grev.

Valve triangular, with somewhat unequal sides and unequally convex margins. Angles rounded, one of them having puncta about 9 in .01 mm., while in the other two the puncta are about 5 in .01 mm. Surface flat, with subquadrate reticulations about

4 in .01 mm., radiating from the centre toward the margin, where they are about 5 in .01 mm.

L. of s. .072 mm.

Fossil in the Miocene deposits of Petersburg and Richmond, Va.

61. **Biddulphia heteropora** (Grun.).

Triceratium (*Biddulphia*) *heteroporum* Grun., V. H. Syn., Pl. 112, fig. 2.

Valve triangular, with nearly straight sides and slightly unequal and somewhat obtuse angles. Surface slightly convex, with rounded puncta which are scattered, except at the angles where they are crowded, and at the margins where they are arranged in short parallel rows, about 5 in .01 mm. At the centre a small circle of very distinct puncta is seen. L. of s. .125 mm.

Fossil at Santa Monica (V. H.), Redondo Beach, Cal.

62. **Biddulphia tessellata** (Grev.).

Triceratium tessellatum Grev., T. M. S. (1861), 71, Pl. 8, fig. 14.
Triceratium robustum Grev., T. M. S. (1861), 71, Pl. 8, fig. 15.
Triceratium amoenum Grev., l. c. 75, Pl. 9, fig. 7.
Triceratium secernendum A. S., Schmidt, Pl. 76, fig. 34.
? *Triceratium Fischeri* A. S., Schmidt, Pl. 76, fig. 34.

Valve triangular, with straight or slightly concave sides and rounded angles. Surface usually somewhat convex at the centre, with rounded, elliptical, hexagonal or subquadrate reticulations about 3 in .01 mm., but smaller at the centre, arranged in more or less concentric rows and much smaller at the extremities of the angles which appear hyaline under low magnification, where they are from 8 to 15 in .01 mm. Small puncta occasionally occur scattered among the larger.

L. of s. .049 mm. to .099 mm. Quite variable in size and the coarseness of markings.

Fossil in the Miocene deposits of the Eastern States.

As remarked by Cleve, the group to which the present species belongs is " extremely difficult to exactly determine." The form known as *T. tessellatum* is well described by Greville, but in the case of *robustum* and *amœnum* no sufficiently accurate and distinct differences are noted. *T. robustum* is described as having hyaline spaces at the extremities of the angles, but a careful examination will disclose a fine and indistinct punctation extending to the apices. *T. amœnum* is merely a small form, while *T. secernendum* differs from the type only in being somewhat irregular in outline and in having more rounded angles. Familiarity with the Nottingham deposit will show so many intermediate variations that the number of species might be indefinitely increased, if the distinctions in the above forms are assumed to be specific. Many forms are with difficulty distinguished from *B. Reticulum* E. The variations are well shown also in material from Weymouth, N. J., artesian well.

63. **Biddulphia Reticulum** (Ehr.).

Triceratium Reticulum Ehr., Berl. Akad. (1844), 88 ; Mik., Pl. 18, fig. 50, Pl. 33, 16, fig. 13 ; Schmidt, Pl. 76, fig. 4.
Triceratium sculptum Shadb., T. M. S. (1854), 15 ; Pl. 1, fig. 4 ; Schmidt, Pl. 76, figs. 9, 10, 11, 12, 31.
Triceratium obtusum Br. (not Ehr.).
Triceratium punctatum Br. (not Wall.), Schmidt, Pl. 76, figs. 19, 20.
Triceratium Browneanum Grev.
Biddulphia sculpta (Shadb.) V. H.

Valve triangular or polygonal, with either straight or concave sides. Angles rounded, sometimes produced. Surface slightly elevated at the centre and at the angles, with puncta about 4 in .01 mm., angular, irregular and unequal, mostly larger at the centre. Three or four spines are occasionally noticed about halfway between centre and sides. Groups of puncta frequently occur arranged in three or four small circles. Frustules in zonal view but slightly developed. L. of s. .059 mm.

Generally distributed along the coast, especially southward. Fossil in the Miocene and later deposits of the Eastern States.

An examination of many specimens from various localities leads me to the conclusion that if we take the form usually called *Triceratium punctatum* Br. as the type, the forms named *sculptum* Shadb., *tessellatum* Grev., *robustum* Grev. and several others may be included as variations of one species. In order, however, to avoid confusion and because of the difference in the arrangement of puncta between *tessellatum* and *robustum* on the one hand and *Reticulum* and like forms on the other, I consider them for the present as distinct. The puncta in all the forms above-mentioned are usually more or less irregular, the centre in large specimens is more likely to show the slight depression within the central elevation than in smaller forms, and the sides and angles vary according to the ordinary laws of plant nutrition. Shadbolt bases *sculptum* upon the presence of three "pseudo-nodules," but, as has been noticed by others, these do not always appear in specimens otherwise similar. A specimen in my collection from a fossil deposit at Absecon, N. J., in which four "pseudo-nodules" are plainly visible, shows the unstable character of this distinction. Two to four spurs may be seen on recent specimens from Yucatan and west coast of Florida which show at the same time the markings of *T. sculptum*. A specimen from a fossil deposit at Newbern, N. C., which somewhat approaches *robustum* shows four very small spines at about one-half the length of radius (see remarks of Schmidt about figs. 4 and 26, Pl. 76).

64. **Biddulphia inelegans** (Grev.).

> *Triceratium inelegans* Grev., T. M. S. (1866), 8, Pl. 2, fig. 21; Schmidt, Pl. 81, fig. 16 (not *T. obtusum* Ehr., as suggested by several authors, as the angles are not the same).
> *Triceratium Jucatense* Grun., Schmidt, Pl. 76, fig. 13.

Valves triangular, with straight, concave or convex sides which are frequently unequal. Angles obtuse. Surface with rounded, irregular and scattered puncta, about 2 or 3 in .01 mm. At the angles, which are sometimes slightly elevated, the puncta are about 7 or 8 in .01 mm. L. of s. .089 mm. to .118 mm.

Var. *areopora* Grun. has straight sides and scattered puncta.

Var. *Jucatensis* Grun. has straight sides and larger puncta.

Var. *micropora* Grun. has usually smaller and more crowded puncta.

Campeachy Bay. Fossil at Santa Monica and Redondo Beach, Cal.

65. **Biddulphia parvula** (Jan. and Rab.).

> *Amphitetras parvula* Jan. and Rab., Diat. Honduras, 4, Pl. 1, fig. 4 (not *A. parvula* Grev.).
> *Triceratium zonatulatum* Grev., T. M. S. (1865), 102, Pl. 9, fig. 17; Schmidt, Pl. 77, figs. 33-37, Pl. 94, fig. 9

Valve triangular or quadrangular, with deeply concave sides, producing, in the latter form, a cruciform outline with rounded angles. Surface of central part hyaline, excepting a few indistinct puncta, but at the angles the puncta are in parallel rows about 8 in .01 mm. W. of v. .059 mm.

Honduras. Rare. The triangular form not yet noticed in North America.

66. Biddulphia semicircularis (Br.).

Triceratium semicirculare Br., M. M. J. (1853), 252, Pl. 4, fig. 21; V. H. Syn., Pl. 126, fig. 20.
Triceratium obtusum Ehr. (in part), Mik., Pl. 18, fig. 49.
Euodia Brigtwellii Ralfs, Prit., 852.

Valve lunate, appearing as if divided half-way between the centre and the obtuse ends by two very faint costate lines. Surface elevated at the centre and at the ends, with rounded puncta, about 3 in .01 mm., concentric and radiating from a hyaline centre, smaller at the ends. L. of v. averages .099 mm.

Fossil in the Miocene deposits of the Eastern States.

Biddulphia semicircularis Asburyana Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 469, Pl. 24, fig. 3.

Valve arcuate with the ends produced and elevated into processes. Surface not divided by costate lines, convex, with rounded puncta, about 6 in .01 mm. near the hyaline excentric space, increasing in size to about 1½ in .01 mm. at the margin. L. of v. .181.

Not uncommon in deposit (Miocene) at Asbury Park, N. J.

67. Biddulphia Testudo (Brun.).

Biddulphia ? ? K. and S., Bull. Torr. Cl. (1889), 208, Pl. 93, fig. 4.
Tabulina Testudo Brun., Diat. Jap., 59, Pl. 6, fig. 8; Schütt, 82, fig. 131. Referred by De Toni to *Cheloniodiscus*, which, however, I think it does not resemble. It appears to be a true *Biddulphia*.

Valve suborbicular or oblong-elliptical, somewhat flattened, but with four large process-like, slight elevations, two of which are near each end. Surface traversed by an indefinite number of wide, hyaline, curved lines. Two of the lines are more or less transverse to the major axis, while the others appear to radiate indefinitely from a central space and anastomose. Surface with unequal and scattered puncta, about 8 in .01 mm. L. of v. .066 mm. to .089 mm.

Frustule in zonal view quadrangular, the connective zone having transverse rows of puncta more distinct than those on the valve.

Fossil in the Miocene deposits of Atlantic City and Weymouth, N. J.

68. Biddulphia Shulzei Boyer.

Biddulphia Shulzei Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 470, Pl. 24, figs. 7, 8.

Valve elliptical, slightly elevated toward the centre, with a large, rounded, process-like elevation at each end. Surface with rounded, oblong puncta averaging 5 in .01 mm., but for the most part scattering, leaving numerous hyaline spaces. Owing to the irregularity in the distribution of the puncta the circumference of the valve appears to show a scalloped border. L. of v. .115 mm.

Distinguished from *B. Testudo* in having but two processes and in being without the hyaline lines which cross the valve of the latter. A variety with three processes also occurs.

Fossil at Weymouth, N. J.

DOUBTFUL SPECIES.

Triceratium indentatum K. and S., *Torr. Bull.* (1889), 210, Pl. 92, fig. 4; Wolle, Pl. 78, fig. 7; De Toni, 942. From photographs sent me by Dr. Ward, of Poughkeepsie, and Mr. Kain, the following description may be given: Valve triangular, sides convex. Angles not elevated, bidentate. Surface flat, reticulate, the reticulations subquadrate or hexagonal, 2 to 4 in .01 mm., radiating from the centre where they are larger. L. of s. about 08 mm. This form may, possibly, be classed among the *Pseudo-Coscinodisci*, unless it should prove to be abnormal. I have not seen any specimens, but the photographs give the general appearance of a small form of *B. Americana* (Ralfs) with the angles notched at the apices. The absence of processes as well as angles resembling the ordinary types precludes its admission among the *Biddulphiæ* until it has been further examined. Fossil in the artesian well, Atlantic City, N. J.

Triceratium (Biddulphia) obliquum Grun., *V. H. Syn.*, Pl. 110, fig. 11; Wolle, Pl. 106, fig. 10. Santa Monica, Cal.

Triceratium Pileolus E., *Berl. Akad.* (1844), 205; *Mik.*, Pl. 35*A.*, 21, fig. 17; *K. S. A.*, 140; Weisse, 242, Pl. 1, fig. 20; *Prit.*, 856; Wolle, Pl. 108, fig. 1. This form is said by Brightwell to be allied to *T. brachiolatum* Br. (*M. M. J.* (1853), 248, and (1856) 272), which by Ralfs is said to equal *T. Pileus* E. Ralfs also gives it as equivalent to *T. obtusum* Br. (not E.) (see under *B. Reticulum* (E.), of which it may be a variation). As *T. obtusum* Br. is the only one of the above forms said to be American, it may be unnecessary to refer to the synonymy further.

Triceratium subcornutum Grun., Schmidt's *Atlas*, Pl. 99, fig. 15–18. Campeachy Bay. Near *T. elegans* Grev.?

Triceratium tripartitum Grun., *V. H. Syn.*, Pl. 110, fig. 8; Wolle, Pl. 100, fig. 5; De Toni, 945. Campeachy Bay.

Triceratium uncinatum A. S., *Atlas*, Pl. 94, fig. 4; Wolle, Pl. 102, fig. 12. Pacific coast of Central America.

Species Known Only by Name.

Biddulphia gigas E., *Berl. Akad.* (1844), 265; *Mik.*, Pl. 33, 12, fig. 11; *Prit.*, 849; Wolle, Pl. 103, fig. 11. Ralfs (in *Prit.*) gives the following description: "Large, very turgid at the centre, rough, without distinct granules, laterally five-jointed, having a large, oblong (pseudo-) opening at each attenuated apex." Apparently the above applies to large forms of *B. tridens* (E.) with the processes broken off. The habitat attributed by Ralfs to Ehrenberg is "Bermuda" (Nottingham), but Ehrenberg in *Mik.*, Pl. 33, 12, fig. 11, gives the Columbia river as the locality. From the uncertainty as to description, figure and locality the name may be dropped without loss.

The figure given by Wolle, Pl. 103, fig. 12, is, as he states, a *Melosira*. See Bailey, *Sil. Jour.*, 1845, 322, under *Gallionella*.

Biddulphia perpusilla "Bail. Coll.," *Habirshaw Cat.*, De Toni, 878.

Triceratium aculeatum E. (not Grev.) E., *Mik.*, supplement, 16; De Toni, 972; Wolle, Pl. 25, fig. 21. There is no description given of this form so far as I can discover. Wolle has made the mistake of taking Greville's description of a form from Barbados (*Triceratium aculeatum* Grev., *T. M. S.* (1861), 45) for Ehrenberg's form, and has constructed a "figure suggested by description"! Ehrenberg's form is said to be found in the rice fields of Georgia.

Triceratium interruptum "Bail. Coll.," *Habirshaw Cat.*

Triceratium Parma Bail. Prof. H. L. Smith states (*The Lens*, I, p. 232) that Bailey's "*Triceratium Parma* is only a triangular form" of *Stictodiscus Californicus.*

"*Triceratium regina* Heib." of Wolle, Pl. 105, fig. 17, is evidently a typographical error and should be *Trinacria regina* Heib., but Wolle's figure does not correspond to Schmidt's, from which it is said to be taken, and is not the figure of a *Trinacria.*

SPECIES EXCLUDED.

Amphitetras cruciata Jan. and Rab., *Diat. Hond.*, 4, Pl. 1, fig. 5; De Toni, 905. This form is the same as *Amphitetras crucifera* Kitton, *Science Goss.* (1867), 271, fig. 285; Ralfs in *Prit.*, 858; De Toni, 908, and is also equal to *Triceratium cruciatum* Leud.-Fort., "Ceylon," 59. It is a variety of *Rhaphoneis*, and is given in *V. H. Syn.*, Pl. 116, fig. 16, as *Rhaphoneis amphiceros tetragona* Grun., and by Cleve, *Vega*, pp. 449, 507, Pl. 37, fig. 52, *b* and *c*, as *Rhaphoneis amphiceros cruciata.* Habitat, Honduras.

Amphitetras crucifera Kitton. See under *Amphitetras cruciata.*

Amphitetras parallela E.; *Mik.*, Pl. 19, fig. 20; Kütz., *S. A.*, 134.

Triceratium parallelum (E.) Grev.; *T. M. S.* (1865), 104, Pl. 9, figs. 22, 23; Schmidt, Pl. 75, figs. 3, 4, 5, 11, 12, 13, Pl. 76, figs. 14, 15, 16, 17, 18, 30; var. *Coloniensis* Grun., Pl. 81, fig. 1; var. *Balearica* Grun., Pl. 81, fig. 2; Grun., *Alg. Nov.*, 24, 102; *V. H. Syn.*, Pl. 111, figs. 1–6; Wolle, Pl. 100, figs. 11, 12, 15; *Triceratium obtusum* (E.) Cleve, *Diat. W. Ind.*, 16; *Triceratium Gruendleri* A. S., Pl. 75, fig. 10 (?); *Nothoceratium?* *parallelum* (Grev.) De Toni, 915.

The triangular forms of *Triceratium parallelum* (E.) Grev. and the vars. *Coloniensis* and *Balearica* are abundant in Campeachy Bay. As remarked by Van Heurck, *T. obtusum* E. and *T. parallelum* (E.) Grev. are the same in part. Ehrenberg's form from Richmond is possibly equivalent to Ralfs' *T. Americanum* (*q. v.*), and approaches that from Campeachy Bay, but it is not exactly like Cleve's form in the markings at the centre. Both these forms and *Triceratium Harrisonianum* Norm. are true *Stictodisci*, having the definite arrangement of puncta and the more or less faint parallel or serpentine lines extending inwards from the perimeter. Quite a large number of diatoms figured by Schmidt and by Truan and Witt, among them the beautiful *Stictodiscus adspersus* (A. S.) T. and W., are found at Campeachy Bay and are easily mistaken for Biddulphoid forms, the absence of granules at the centre, usually characteristic of *Stictodiscus*, not being noticeable in small specimens.

Biddulphia bipons E., *Berl. Akad.* (1844), 273 = *Hemiaulus* (Habirshaw).

Biddulphia? lunata E., *Berl. Akad.* (1844), 77; *Mik.*, Pl. 18, fig. 53; *Prit.*, 849 = *Eunotogramma amphioxys* E., *Berl. Akad.* (1855), 302.

Biddulphia membranacea Cleve is not included among North American forms.

Biddulphia Weissflogii Grun. in K. and S., *Bull. Torr. Cl.* (1889), 208, as stated by Mr. Kain later, is *Biddulphia Baileyi* Wm. Sm. = *Biddulphia Mobiliensis* (Bail.) Grun.

Biddulphia Woolmanii K. and S., *T. B. C.* (1889), 74, Pl. 89, fig. 3; Wolle, Pl. 98, fig. 4; De Toni, 872. This form is identical with *Salacia Boryana* Pant., a specimen of which I have from Borostelek, Hungary. Van Heurck (*Diat.*, 359) considers *Salacia* or *Castracania* (new genus created by De Toni for this species, p. 750) as equivalent to *Tetracyclus*, and states that it presents the closest affinity to *T. Rhombus.* There is no doubt, I think, that it is a *Tetracyclus*, and I had considered it as probably identical with *T. ellipticus* (E.) Grun., having found it in a fossil deposit from Oregon where it was very abundant. Ehrenberg's material was from the "Columbia river," and, possibly, from the same source (John Day Valley). There is no difference between the forms from Oregon and those from Atlantic City, except that in the latter they are frequently corroded. See Schütt, 102, fig. 180, where it is given as *Tetracyclus* (*Castracania*) *Boryanus* (Pant.) De Toni.

Nothoceratium? parallelum (Grev.) De Toni. See under *Amphitetras parallela* E.

' *Triceratium Amblyoceros* E. = *Actinoptychus.* See under *Biddulphia Americana.*

Triceratium Brightwelli West = *Ditylum.*

Triceratium cinnamomeum Grev., *M. M. J.* (1863), 232; Wolle, Pl. 75, fig. 11, Pl. 105, fig. 18 = *Cestodiscus cinnamomeus* (Grev.) Grun.

Triceratium crenatum Kitton = *Ditylum.*

Triceratium cruciatum Leud.-Fort. See under *Amphitetras cruciata.*

Triceratium Ehrenbergii Grun. = *Ditylum.*

Triceratium Gruendleri A. S. See under *Amphitetras parallela.*

Triceratium Harrisonianum Norm. and Grev., *T. M. S.* (1861), 76, Pl. 9, fig. 9; Schmidt, Pl. 75, figs. 14–16, Pl. 81, figs. 8, 9, 17, Pl. 150, fig. 19. A species of *Stictodiscus*. Habitat, Campeachy Bay. The var. *solida* of Walker and Chase (L. N. and R. Diat.), Pl. 3, fig. 12, is also found. See under *Amphitetras parallela.*

Triceratium heterostictum A. S. = *Cestodiscus cinnamomeus* (Grev.) Grun. var. *minor* Grun.; Schmidt, Pl. 151, fig. 28; *V. H. Syn.*, Pl. 126, fig. 2.

Triceratium Marylandicum Br. = *Actinoptychus.*

Triceratium obtusum (E.) Cleve. See under *Amphitetras parallela.*

Triceratium parallelum (E.) Grev. See under *'Amphitetras parallela.*

Triceratium pileatum Grun. = *Pseudo-Coscinodiscus, V. H. Syn.*, Pl. 112, fig. 3.

Triceratium receptum A. S. (see under *T. Shadboltii*); Schmidt, *Atlas*, Pl. 81, fig. 10. Santa Monica, Cal. Apparently near the triangular forms of *Biddulphia lœvis* or *convexiuscula.*

Triceratium Shadboltii L. W. Bailey, *B. J. N. H.* (1862), 342, Pl. 8, figs. 60, 61. Not North American. Habitat, San Antonio Bay, Para river, Brazil. From the figures it would appear to be a small form of *Triceratium spinosum* Bail. Schmidt's comparison of *Triceratium receptum* A. S. (*Atlas*, Pl. 81, fig. 10) to this form is evidently a mistake.

Triceratium striolatum Wm. Sm. (not E.) = *Ditylum.*

Triceratium undulatum E. = *Ditylum.*

PORPEIA Bail. (1861).

Valve oblong, tumid in the middle, more or less constricted near the rounded ends, and divided by two transverse septa which extend inward, curving and becoming parallel to the surface.

Analysis of Species.

Septa curved, ... 1. *quadriceps.*
Septa parallel to edges of valve, ... 2. *quadrata.*

1. Porpeia quadriceps Bail. (in lit.).

> *Porpeia quadriceps* Bail., Prit., 850, Pl. 6, fig. 6. Var. *intermedia* Grun., V. H. Syn., Pl. 95 *bis*, fig. 14; Schmidt, Pl. 142, figs. 46-52.
> *Biddulphia clavulata* Ehr., Berl. Akad. (1861), 94?

Valve rounded at both ends, which are constricted into lobes and inflated at the middle. Ends of valve more or less elevated.

From the junction of each process with the valve a septum extends downward curving more or less toward the centre. Surface of valve usually flattened and covered with granules, which are more crowded on the processes, about 6 in .01 mm. Zonal view quadrangular, the connective zone having puncta in parallel rows. L. of v. averages .029 mm.

Campeachy Bay; Gulf of Mexico.

2. **Porpeia quadrata** Grev.

Porpeia quadrata Grev., T. M. S. (1865), 53, Pl. 6, fig. 20 ; Schmidt, Pl. 142, fig. 38 and figs. 53-56 (fig. as *quadriceps*).

Valve as in *quadriceps*, except that the processes are but slightly elevated and the septa extend inward in a direction more or less parallel to the edge of the valve as seen in zonal view. L. of v. .082 mm. Connected with the preceding by intermediate forms. The variations in the curves of the septa are determined by the length of the valve.

Fossil at Santa Monica, Cal.

TERPSINOË Ehr. (1843).

Valve elliptical or triangular, more or less constricted by septa which are prominent and in zonal view appear either straight or curved at the ends. Surface reticulated or punctate, sometimes indistinctly so. Closely allied to *Anaulus*, from which it is chiefly distinguished by the character of the septa.

Analysis of Species.

Valves elliptical, reticulate or coarsely punctate:
  Septa curved:
    Surface not reticulate, ... 1. *Musica.*
    Surface reticulate,. . . . . 2. *intermedia.*
  Septa not curved, ... 3. *Brebissonii.*
Valves elliptical or triangular, indistinctly punctate:
  Puncta radiating from hyaline centre, . . . 4. *Americana.*
  Puncta scattered except at angles and centre, 5. *Novæ-Cæsareæ.*

1. **Terpsinoë Musica** Ehr.

Terpsinoë Musica Ehr., Amer., Pl. 3, 4, fig. 1 ; 3, 7, fig. 30 ; Mik., Pl. 34, 6, *A*. 8 ; Schmidt, Pl. 199, figs. 9-13, Pl. 200, figs. 7, 8.
Terpsinoë magna Bail., L. W. Bail., B. J. N. H., 340, figs. 46, 50-54.
Terpsinoë tetragramma Bail., *l. c.*
Terpsinoë minima Bail., *l. c.*

Valve elliptical, with undulating sides and lobed at the ends, divided by septa into three or more parts. Surface with coarse puncta, about 8 in .01 mm., not radiating, much finer at the ends. On the connective zone the puncta are about 12 in .01 mm. An irregular nodular centre is usually visible. Frustule in zonal view quadrangular, the septa with their inner margins curved and thickened on the edges, presenting the appearance of musical notes.

Variable in size and in the divisions of the valves. L. of v. averages .165 mm.

Marine and fresh water. Delaware river mud (Lewis); St. Mary's river, Ga. (Lewis). More common southward.

2. **Terpsinoë intermedia** Grun.

Terpsinoë intermedia Grun., Diat. Franz Jos. Land, 59 ; Schmidt, Pl. 199, figs. 1–8 ; Pl. 200, figs. 1–6 ; Pl. 198, fig. 65.

Valve elliptical with undulating sides, and divided by septa into several divisions. Surface punctate and reticulated, sometimes indistinctly so, the reticulations irregular and unequal, about 2 or 3 in .01 mm. Septa usually not thickened as in *Musica*, but bent near the edge. The nodular centre is, in most specimens, quite pronounced. L. of v. .174 mm.

Mobile (Schmidt). Fossil at Nottingham (Brun), Atlantic City (K. and S.), Asbury Park and Longport, N. J.

Terpsinoë intermedia latecavata (Brun) differs from the type in outline, which is rhombic-elliptical with produced ends. Brun remarks that this form belongs to *Terpsinoë* as much as to *Anaulus* and is near *T. intermedia* Grun. See on *Anaulus* (*Terpsinoë*) *latecavatus* Brun, *Diat. Jap.*, 16, Pl. 1, fig. 13.

Fossil at Nottingham (Brun).

3. **Terpsinoë Brebissonii** (Kütz.) V. H.

Terpsinoë (*Pleurodesmium*) *Brebissonii* (Kütz.) V. H., Diat., 453.
Pleurodesmium Brebissonii Kütz., Bot. Zeit. (1846), 248 ; Schmidt, Pl. 200, figs. 15–19.

Valve elliptical with undulating sides and slightly lobed at the ends. Surface divided by septa into five compartments, with puncta averaging 6 in .01 mm. L. of v. .066 mm.

Frustule in zonal view quadrangular, with septa capitate but not appearing curved. Connective zone with fine puncta, about 15 in .01 mm. The frustules are said by De Brébisson to be connected by "threads," and by Van Heurck by "short processes in the form of feet," which are best seen in specimens mounted *in* *situ* and appear to belong to the membrane enveloping the frustules.

Cedar Keys, Fla., and southward

4. **Terpsinoë Americana** (Bail.) Ralfs.

Tetragramma Americana Bail., N. Sp., 7, fig. 1.
Terpsinoë Americana (Bail.) Ralfs, Prit., 859 ; Schmidt, Pl. 200, figs. 9–13.

Valve with undulating outline, lobed at each end, and lobed or inflated at each side; divided by septa into three or more parts. Surface with coarse but rather indistinct puncta, about 6 in .01 mm., which radiate interruptedly from a hyaline centre. Frustule in zonal view quadrangular with septa extending about halfway into the valve. L. of v. .059 mm.

Marine and fresh water. Hudson river; Rockaway, L. I.; Charleston; St. Augustine; Tampa Bay (Bail.). Fossil at Atlantic City and Harvey Cedars, N. J.

5. **Terpsinoë Novæ-Cæsareæ** Boyer.

Hydrosera (*Terpsinoë ?*) *Novæ-Cæsareæ* Boyer, Torr. Bull. (1895), 263 ; Lewis Woolman, Ann. Rep. Geol. Sur. N. J. (1894), Pl. 6, fig. 2 ; Le Diatomiste, 2, 207.

Valve triangular, sides concave. Angles broad at the base, equally three-lobed. Surface flat, divided by straight septa separating the angles from the central part, which is for the most part hyaline, except at the centre, where a few puncta are seen. Angles with faint, scattered puncta, about 7 in .01 mm. Connective zone with faint puncta. W. of v. averages .062 mm. Fossil in artesian well, Wildwood, N. J.; Cold Spring, L. I. (Reis)?

HYDROSERA Wallich (1858).

Valves quadrangular in zonal view and elliptical or triangular in valve view. The angles are separated from the central part by septa which extend inward but a short distance. There is usually present on one side of each valve an indistinct mark. Surface of valves granular or cellular.

Hydrosera triquetra Wall.

Hydrosera triquetra Wall., M. M. J. (1858), 251, Pl. 13, figs. 1–12 ; Schmidt, Pl. 78, figs. 36–38 ; Deby, Jour. de Micrographie (1891), Pl. 1, fig. 1.
Not *Triceratium Javanicum* Cleve.

Cleve (*N. and L. K. D.*, 24) considers this form possibly a variety of *Hydrosera triquetra* Wall. Both Deby and De Toni consider the two equivalent. A slide in my collection of *T. Javanicum* Cleve, mounted by Brun, shows the valve with unequal granular markings, more closely resembling those of *H. Whampoense* than the markings of *H. triquetra.*

Valve triangular or elliptical, sides slightly convex, the angles constricted by strong septa which separate them from the central part. Surface with angular reticulations, about 6 in .01 mm. at centre and increasing outward to about 3 in .01 mm., the extremities of the angles appearing hyaline. Inner surface or secondary layer of valve punctate, somewhat as in *Biddulphia Favus,* but the puncta are coarser. Near one of the sides is frequently seen below the surface of the valve a line with two or three granules, which Mr. Deby well remarks are " often illusory." The line appears to be a projection of a siliceous plate from the cell wall and is more easily seen if the valve is examined from the under side. Pritchard's figures (*Inf.*, Pl. 6, figs. 8, 13) exaggerate the " *stigmata.*" Zonal view quadrangular, the septa entering the valve obliquely. Connective zone appearing hyaline. I have not been able to find in the fossil forms the minute spines said to occur at the extremities of the angles. L. of s. .099 mm. to .132 mm.

Fossil at Atlantic City, N. J., in the triangular form only. Carpentaria Bay (Schmidt).

ANAULUS E. (1844), Em. V. H. (1881).

Valves more or less elliptical or lunate, divided into three or more parts by septa which usually constrict the margins. Surface without elevation, with puncta usually radiate from an occasionally nodular centre or arranged in transverse lines.

Analysis of Species.

Valves elliptical:	
Without central nodule, ...	1. *Mediterraneus.*
With central nodule:	
Not beaked at extremities, ...	2. *birostratus.*
Beaked at the extremities, ...	3. *acutus.*
Valves lunate (*Eunotogramma*):	
Puncta somewhat scattered, ...	4. *lævis.*
Puncta in transverse rows, ...	5. *debilis.*

1. **Anaulus Mediterraneus** Grun.

Anaulus Mediterraneus Grun., V. H. Syn., Pl. 102, fig. 8–11.

Valve elliptical, rounded at the ends, divided by two septa into three parts. Surface convex with scattered puncta, 5 or 6 in .01 mm. No central nodule visible. L. of v. .066 mm.

Fossil at Atlantic City, Asbury Park and Longport, N. J. Occasional specimens from Weymouth, N. J., show but one septum.

Anaulus Mediterraneus intermedius Grun.

Anaulus Mediterraneus var. *intermedia* Grun., V. H. Syn., Pl. 102, fig. 9.

Valve constricted at the centre and at the ends; otherwise as in *A. Mediterraneus.*

Fossil in the Miocene deposits of California and the Eastern States.

There are several intermediate variations found in the Nottingham, Longport and other deposits, which lead to the conclusion that the above forms might be united under one specific name.

2. **Anaulus birostratus** Grun.

Anaulus birostratus Grun., V. H. Syn., Pl. 22 *bis*, fig. 15; Pl. 103, figs. 1–3.

Biddulphia birostrata Grun., Wien Verhandl. (1863), 158, Pl. 13, fig. 23.

Valve elliptical-lanceolate, usually constricted near the ends; angles obtuse. Surface divided by septa into three parts, the central one being square in outline, with scattered puncta, about 4 in .01 mm., more evident near the centre, at which a nodule is usually quite apparent. L. of v. .105 mm.

Fossil in the Miocene deposits of California and the Eastern States. Found also living on the shores of Peru, Virgin Islands, West Indies, etc., and may, therefore, be looked for northward.

3. **Anaulus acutus** Brun.

Anaulus acutus Brun., Le Diatomiste, 2, 231, Pl. 20, figs. 15–18.

Valve more or less constricted at the middle with the ends produced. Near *A. birostratus*, from which it differs, according to Brun, in having its valves, seen in zonal view, "joined by their extremities in the form of beaks." Puncta scattered, 5 or 6 in .01 mm. L. of v. .105 mm.

Fossil at Santa Crux (Brun); Wildwood, N. J. (Brun); Redondo Beach, Cal.

4. **Anaulus lævis** (Grun.) V. H.

Eunotogramma læve Grun., V. H. Syn., Pl. 126, figs. 6, 7, 9, 15; Schütt, fig. 171, *A*, *B*.

Valve lunate, with obtuse ends; and with or without slight constrictions at the prominent septa, which usually number from four to six. Surface marked with rather indistinct puncta, somewhat scattered, about 8 in .01 mm. Zonal view sharply quadrangular, the connective zone having transverse but somewhat distant rows of fine puncta. L. of v. .046 mm.

Coast of North Carolina and Florida; stomachs of fish, coast of South Carolina. Not common. Fossil at Buckshuten, N. J.; Atlantic City artesian well, N. J.

5. **Anaulus debilis** (Grun.) V. H.

Anaulus debilis (Grun.), V. H. Syn., 202.
Eunotogramma debile Grun., V. H. Syn., Pl. 126, figs. 17, 18, 19.

Valve lunate with margins entire. Transverse septa more numerous than in *A. lævis.* Surface with puncta in transverse rows, about 15 in .01 mm. L. of v. .049 mm.

Very near *A. lævis,* with intermediate forms.

West river, Conn.; Campeachy Bay (V. H.).

Species Excluded.

Anaulus Campylodiscus E., *Prit.*, 859; *Euodia Frauenfeldii* Grun., *Wien Verhandl.* (1863), 158, Pl. 14, fig. 19; *Eunotogramma Frauenfeldii* Grun., *V. H. Syn.*, Pl. 126, fig. 14; De Toni, 892. Habirshaw refers this to Grunow's form, apparently because Grunow says (*l. c.*) that the latter appears to bear some resemblance to the quite insufficiently described *Anaulus Campylodiscus.* The reference is probably incorrect. Ehrenberg's locality is given as "Bermuda" (Nottingham), and his form may possibly be *Biddulphia semicircularis* (Br.).

Eunotogramma amphioxys E., *Berl. Akad.* (1855), 302; De Toni, 892. This form is given as equivalent to *Biddulphia? lunata* E., *Berl. Akad.* (1844), 77; *Mik.*, Pl. 18, fig. 53; Kütz., *S. A.*, 138; *Prit.*, 849. It is described in *Prit.* as "three-lobed, smooth, slightly curved, lunate, with subacute horns." The form is unknown to me.

HUTTONIA Gr. and St. (1887).

The generic diagnoses not yet having been made and the genus ncluding species unlike the only American form thus far discovered, it is considered unnecessary to do more than give specific characteristics. De Toni remarks that the "genus is scarcely to be preserved" and that "perhaps it should be united with *Triceratium* or with *Odontella.*" The processes appear like those of *Cerataulus,* while the outline and septa partake of the characteristics of *Anaulus Mediterraneus.*

Huttonia Reichardtii Grun.

Huttonia Reichardtii Grun., Just's Jahresb. (1887), 279; Schmidt, Pl. 116, fig. 4.
Cerataulus (?) *Reichardtii* Grun., Wien Verhand. (1863), 158, Pl. 13, fig. 22.

Valve elliptical, divided by two somewhat irregular, transverse, imperfect septa. Surface not elevated, punctate, the puncta about 9 in .01 mm., in irregular, somewhat oblique rows. Near each end, on opposite sides, an indefinite, truncate process extends obliquely outward. Zonal view quadrangular. L. of v. .049 mm. In a specimen from Wildwood, N. J., one of the processes is obsolete.

Fossil in the Miocene deposits of Virginia (Grun.); Atlantic City (K. and S.); Weymouth, N. J.; Wildwood, N. J. Rare.

HEMIAULUS Ehr. (1844) Em. H. L. Smith.

Valves elliptical or triangular, with the ends or angles usually extended into robust processes which are frequently mucronate. Surface usually more or less depressed at the centre, but occasionally divided by costæ into rounded elevations, with puncta usually coarse and prominent. Valves of same frustule not always equal.

Analysis of Species.

- Valves triangular, ... 1. *Solenoceros.*
- Valves elliptical:
  - Processes short, ... 2. *bipons.*
  - Processes long:
    - Valves costate:
      - Surface divided into elevations, . . . 3. *polymorphus.*
      - Surface not so divided, ... 4 *polycistinorum.*
    - Valves not costate:
      - With minute spine near end of process, . . 5. *Kittonii.*
      - With spine on end of truncate process, . . 6. *Monicæ.*
      - Without spines, ... 7. *Californicus.*

1. Hemiaulus Solenoceros (Ehr.)

Triceratium Solenoceros Ehr., Berl. Akad. (1844), 273 ; Schmidt, Pl. 77, fig. 21 ; Pl. 96, fig. 11 ; Pl. 97, figs. 6, 7.
Triceratium ligulatum Grev., T. M. S. (1864), 91, Pl. 13, fig. 9.
Triceratium Kittonianum Grev., T. M. S. (1865), 8.

Valve triangular, with deeply concave sides and angles produced into slender arms, from the extremities of which extend at right angles truncated, "hammer-like" processes which are usually less than .01 mm. in height. Surface elevated at the nodular centre, from which puncta about 5 in .01 mm., although somewhat larger toward the extremities, radiate along the produced angles in three or four nearly parallel rows. W. of v. .132 mm.

Fossil in the Miocene deposits of the Eastern States.

Greville, in his description of *Triceratium Kittonianum,* lays stress on the presence of the pseudo-nodule which, he says, "like a hammer," projects above and below the connective zone, and also upon the hexagonal reticulations as distinguishing his species from *Triceratium Solenoceros* Ehr. An examination of numerous specimens from the Nottingham deposit shows that the reticulation is more or less hexagonal in all and that there is considerable variation in the amount of elevation of the processes, as is mentioned by Heiberg in his description of *Trinacria Regina,* due occasionally to their being broken off, but quite often to their imperfect development, it being somewhat difficult to find valves in which all three processes are of exactly the same height. While I have not seen the curved spines characteristic of *Trinacria* at the apices of the processes, yet the roughened edges occasionally appear to indicate the possibility of their having been originally present, and the close resemblance of the American forms to those described by Heiberg under *Trinacria* leave no doubt, I think, of their generic character.

Trinacria is united to *Hemiaulus* in accordance with the views of Van Heurck, Brun and others, the difference being chiefly that of outline. *Trinacria excavata* Heib., which is given by some authors as equivalent to this form, differs from it in having much larger marginal reticulations. The *Habirshaw Catalogue* gives *Trinacria Regina* Heib. as a synonym, but I think this is also distinct. The three forms are, however, closely allied.

2. Hemiaulus bipons (Ehr. ?) Grun.

Zygoceros bipons Ehr., Berl. Akad. (1844), 273.
Hemiaulus bipons (Ehr. ?) Grun., Fr. Jos. L., 13; V. H. Syn., Pl. 103, figs. 6–9.

Valve elliptical-lanceolate, acute at the ends, divided into three nearly equal parts by two robust transverse costæ. In zonal view the surface is depressed at the centre, the sharply defined edges of valve extending into a double keel along the short processes, each of which bears a short, stout, incurved spine. Puncta rounded, 3 in .01 mm. L. of v. .075 mm.

Fossil in the Miocene deposits of the Eastern States, especially at Nottingham and Richmond.

3. Hemiaulus polymorphus Virginicus Grun.[6]

Hemiaulus polymorphus Virginicus Grun., Fr. Jos. L., 14, Pl. *B*, fig. 46; Schmidt, Pl. 143, fig. 31.

Valve elliptical-lanceolate, with the margin apparently but not really constricted by the transverse costæ which, variable in number, divide the surface into rounded elevations, of which the central is usually the largest and more elevated. Processes robust, seldom more than half the length of valve, each with a strong inwardly curved spine .01 mm. in length. Puncta 6 or 7 in .01 mm., not in regular rows. L. of v. averages .048 mm.

Fossil at Richmond, Va.

4. Hemiaulus polycistinorum Ehr.

Hemiaulus polycistinorum Ehr., Mik., Pl. 36, fig. 43, *a–d*; Schmidt, Pl. 143, figs. 23–29.

Valve elliptical-lanceolate, acute at the ends, divided by two or more costæ which are usually but slightly depressed. Surface either depressed toward the centre or flat. Processes usually long and robust, terminated by a short, stout, incurved spine. Puncta rounded, pearly and prominent, especially on the processes, where they are about 3 in .01 mm. L. of v. averages .033 mm.

Nottingham ("Stratford Cliffs," Ehr.).

5. Hemiaulus Kittonii Grun.

Hemiaulus Kittonii Grun., V. H. Syn., Pl. 106, figs. 6–9; Schmidt, Pl. 142, figs. 2–8, 11.
Hemiaulus sp. Kitton., J. Q. C. (1870), Pl. 14, fig. 2.

Valve elliptical, without costæ. Surface slightly raised at centre, with puncta in irregular rows on the valve, but parallel on processes, about 10 in .01 mm. Processes slender, .049 mm. in length, incurved, terminated by a fine straight mucronate spine, at the base of which, on the outer edge of each process, a minute spine projects. L. of v. .019 mm.

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[6] Schmidt states (*Atlas*, Pl. 143) that, according to Witt's opinion, *Hemiaulus polymorphus* Grun. is identical with *Hemiaulus Proteus* Heib., and that the latter name has the right of priority. The variety *Virginicus* Grun. and other forms known as *H. polymorphus* differ from *H. Proteus* in not having the margins constricted at the middle.

Vera Cruz. Rare.

6. Hemiaulus Monicæ Grun.

Hemiaulus Monicæ Grun., Fr. Jos. L., 10.

Valve elliptical. Processes robust, short and truncate, tipped with a minute spine. Surface slightly elevated at the centre, with puncta somewhat irregular, 4 in .01 mm., but becoming smaller toward the ends of the processes, where they are about 7 in .01 mm. L. of v. .022 mm.

Near *H. symmetricus* Grev. (*T. M. S.*, 1865, 53, Pl. 6, fig. 22), from which it differs in having the puncta less regularly disposed.

Fossil at Santa Monica, Cal.; Richmond (De Toni).

7. Hemiaulus Californicus Ehr.?

Hemiaulus Californicus Ehr., Mik., Pl. 33, 13, fig. 15.

Valve elliptical with robust processes. Costæ wanting, but in zonal view a slight depression is seen where the processes join the surface. Puncta more or less hexagonal, about 4 in .01 mm., in longitudinal rows. L. of v. .019 mm.

Fossil in California (Ehr.); Richmond, Va.

It is with some hesitation that the above description of specimens in my collection is attributed to *H. Californicus*, as Ehrenberg's figure is not sufficiently clear, but it is evident, I think, that the figure is intended to represent a small form having slight depressions at the junction of processes with the surface, and with puncta in longitudinal rows. The only other species, probably, to which the American forms can be referred is *affinis* Grun., which, however, may be identical with *Californicus*.

PLOIARIA Pant. (1889).

Valves elliptical-lanceolate, elevated at the centre, which is separated from the ends by depressions which appear like costæ. Puncta coarse. In general the valves resemble those of *Hemiaulus*, but are without processes. Includes but one species.

Ploiaria petasiformis Pant.

Hemiaulus ? petasiformis Pant., Foss. Bacill. Ung., I, 48, Pl. 29, fig. 295.
Ploiaria petasiformis Pant., *l. c. 2*, Pl. 28, figs. 403, 405.

Valve elliptical-lanceolate or elliptical-rhomboidal, acute at the ends, divided transversely by two lines, apparently costæ, into three parts, the two outer being flattened or slightly concave, while the central part is convex. Surface with puncta about 6 in .01 mm., more or less radiating from an apparent nodule which is usually excentric. In zonal view the valves appear petasiform and are slightly unequal. L. of v. .059 mm. to .082 mm.

Fossil at Nottingham and Atlantic City. Not common. Sometimes mistaken for *Hemiaulus bipons* Ehr.

GRAYA Grove and Brun. (1892).

Valve elliptical, appearing hyaline under low magnification. Surface undulating, with fine puncta chiefly along the longitudinal axis and radiating from a nodular centre. Represented by one species which is closely related to *Eucampia*.

Graya Argonauta Grove and Brun.

Grayia Argonauta Grove and Brun., Schmidt, Pl. 192, fig. 11.
Graya Argonauta Brun. and Grove, V. H. Diat., 458, fig. 187.

Valve elliptical or elliptical-lanceolate, with rounded ends. Surface convex, elevated at the centre and ends, but usually appearing beveled at the middle of the sides; subtly punctate near the margin, the puncta becoming more prominent along the longitudinal axis, where they are about 7 in .01 mm., radiating unequally from a nodular centre. Zonal view quadrangular. The connective zone appears to increase by the addition of successive plates which overlap each other. L. of v. .099 mm. to .181 mm. Av. l. of frustule .099 mm.

Fossil in the elliptical form at Nottingham and in the elliptical-lanceolate form at Redondo Beach, Cal.

EUCAMPIA Ehr. (1839.)

Valves elliptical with undulating surface. In zonal view the frustules appear more or less cuneiform and are joined together in spiral chains. They are imperfectly siliceous, notably so in the connective zones which are annulate.

Eucampia Zodiacus Ehr.

> *Eucampia Zodiacus* Ehr., Kreideth, Berl. Akad. (1839), 71, Pl. 4, fig. 8; Wm. Sm., Brit. Diat., 2, 25, Pl. 35, fig. 299; Pl. 60, fig. 299; V. H. Syn., Pl. 95, figs. 17, 18; 95 *bis*, figs. 1, 2.
> *Eucampia? Virginica* Grun., V. H. Syn., Pl. 95, *bis*, fig. 6.
> *Eucampia Britannica* Wm. Sm., Brit. Diat., 2, 25, Pl. 61, fig. 378.

Valve elliptical with rounded ends. Surface with slight elevations at the nodular centre and at the ends, the puncta, about 7 in .01 mm., radiating from the centre to the sides where they are about 10 in .01 mm. Ends of valves hyaline. Zonal view cuneiform, the connective zone annulate and very indistinctly punctate.

L. of v. .115 mm.

Newport, R. I. (Lewis). Fossil in the Miocene deposits of the Eastern States. Rare.

I have not seen the connective zone of the fossil form known as *Eucampia Virginica*, but as the valves correspond exactly with those of *E. Zodiacus*, the two are doubtless identical.

The distinction made by William Smith between the two forms, *E. Zodiacus* and *E. Britannica*, is not specific, as spiral filaments may be seen in which some frustules have their sides "excavated," while others, in the same filament, have merely undulating surfaces without any "foramina between the joints."

LITHODESMIUM, a genus included by Van Heurck, De Toni and others among the Biddulphoid forms, is here omitted as it appears to have scarcely any of their characteristics. Its frustules are united by a reticulated siliceous membrane, and in other respects it appears to be more closely allied to *Ditylum*.

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